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THE GROWTH IN OPPORTUNITIES FOR EDUCATION AND RESEARCH IN PHYSICS DURING THE PAST FIFTY YEARS[1]

By Sir J. J. THOMSON

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DURING the last year we have lost by the death of Professor Albert Michelson a physicist whose work was of quite exceptional importance. The famous experiment known everywhere as the Michelson-Morley experiment has, since it is the basis of the theory of relativity, been largely responsible for the trend of physical thought during the present century. It is a very striking example of the great philosophical consequences which can result from what might seem the rather mechanical process of improving the precision of physical measurements; the importance of the experiment depended entirely on the accuracy of the measurements being great enough to detect with certainty changes amounting only to one part in a hundred million.

The additions to our knowledge of physical phenomena and the number of new ideas introduced into physics since the last anniversary meeting have been so great and cover such a wide range that it would be impossible in the time at our disposal to give an account of them which would be at all adequate or even intelligible to those not already acquainted with them. There are, however, advances of another kind of great importance to the progress of physics which lend themselves more readily to a less inadequate treatment in such an address as this. Such advances are the increase in the opportunities for teaching and research in physics caused by the foundation of many new laboratories, the increase in the attention paid to the teaching of physics in our schools, the endowment of research workers and the increase in the opportunities for these to obtain remunerative employment, the increased recognition of the importance of research in industry and last but not least the improvements

[1] Address of the president of Section A—Mathematical and Physical Sciences, British Association for the Advancement of Science, London, September, 1931.

made in instruments used in research and the increase in the magnitude of the forces, mechanical, electric and magnetic, which are now at our disposal. The physical laboratories in the eighteenth century and the first half of the nineteenth were in the main collections of instruments suitable for experiments to illustrate the lectures of the professor, and the trouble taken over these experiments was, I think, comparable with that taken now. Thus, Wollaston, who was Jacksonian professor at Cambridge at the end of the eighteenth century, is said to have shown over 300 experiments in his annual course of lectures and at a later period Stokes, in his lectures on optics, showed experiments which have not been excelled, for beauty, for educational value, for simplicity or for certainty.

In spite of the fact that until the end of the last century there were but few laboratories available for research much scientific work of the highest importance was accomplished. This, to a very great extent, was due to men who made their own laboratories and bore themselves the cost of the experiments. Thus, Joule made his experiments on the mechanical equivalent of heat in his house at Manchester, Stokes, like Newton, made fundamental experiments on optics in his college rooms, Spottiswoode, Huggins, De la Rue, Lord Rayleigh, and one who has had a long and intimate connection with the British Association—Dr. E. H. Griffiths—also made in their own laboratories and at their own charges additions of great value to physical science.

These men, like Kelvin and Maxwell, had not passed through any course of instruction in practical physics, for no such courses were available; they were in this respect self-taught. Most of them had learned how to use their hands by having had when young some hobby, such as using a lathe, or dabbling in chemical experiments or photography. This training seems to have been effective, for no one can say that their work is amateurish. This raises the important question, may not the present practice in which our advanced students spend a great deal of time in acquiring dexterity in the use of instruments of all kinds be a wasteful one, and could not the student who has learned how to use his hands, has a good knowledge of physics and some practice in making accurate measurements, be trusted to master in a short time the technique of any instrument he might require in a special investigation?

In the early seventies when I first began to study physics at Owens College, Manchester, there were only six physical laboratories in England—the Royal Institution, the Clarendon Laboratory at Oxford, those at University and King's Colleges and the one at the Royal School of Mines in London and one at Owens College, Manchester; there were four in Scotland, one in Ireland and none in Wales. Now the number of physical laboratories at the universities, university colleges, schools, and institutes of technology at which instruction is given in physics, is considerably more than 300. Nearly the whole of this increase has occurred since our last anniversary meeting. The contrast between then and now would be even more marked if we took into account the size of the buildings. Some of the laboratories in those early days were very small affairs. Professor Ayrton described Sir William Thomson's laboratory at Glasgow as consisting at one time of one room and an adjacent coal cellar. When I was at Owens College, Manchester, though it was one of the first places where instruction was given in practical physics, there was no separate laboratory, but only a few rooms and little apparatus. Though the laboratory was small, it was large enough for the few students who worked there, and these had much more freedom and more initiative than would be possible with the large number of students that have now to be provided for. We were allowed to choose our own experiments, we fitted up the experiments for ourselves and if they did not work we tried again, we were not limited with respect to time and we could follow up any point of interest we happened to come across. This rather happy-go-lucky method would be quite impossible with large classes, but it was more interesting and, I think, a better training for research than the highly organized classes which large numbers necessitate. At any rate, I am glad that I came under the old and not under the new system. The new method, however, besides being inevitable has some very decided advantages. There are students who are quite immune when in the lecture room to infection from any physical idea and only get a grip of physical principles when these come before them in the concrete form of an experiment which they make with their own hands; these men learn their theoretical as well as their practical physics in the laboratory, and the nature of the experiments, their number and their sequence are of first-rate importanee; all this requires a great deal of organization.

Science Teaching in Schools and Universities

The movement for including science among the studies pursued in our universities and schools was born almost at the same time as the British Association and the men who took the most prominent part in it, Adam Sedgwick, Herschel and, above all, Whewell, were closely connected with the association. It was some time before the movement led to definite results, but in 1849 the University of Cambridge determined to establish a natural sciences tripos. It was not at first an avenue to a degree and the subjects

were limited to those in which there were professorships in the university, *viz.*, chemistry, mineralogy, human anatomy and physiology, botany and geology. The first examination was held in 1851. There were only six candidates, four were placed in the first class with Professor Liveing at the top.

In 1853 the report of the commissioners appointed to report on the studies at Oxford and Cambridge appeared and contained recommendations in favor of further opportunities for the study of science at the universities. In 1864 the Royal Commission appointed to report on the seven most important public schools recommended that all the boys should receive instruction in science during part at least of their school career. This was not before such a recommendation was needed. For science in schools at that time has been described as being "regarded with jealousy by the staff, with contempt by the boys and with indifference by the parents."

In 1866 there was a valuable report on the teaching of science in schools by a committee of the British Association. In 1867 a commission appointed to consider the education given in those schools not included in the reference to the first commission reported in favor of including science in the curricula of these schools. It should be mentioned that before the publication of these reports, J. M. Wilson, who died only a short time ago, had started science teaching at Rugby, where he was a master.

The fight for the introduction of science teaching in our universities and schools was long, and at times bitter; for some time little progress seemed to be made, but in 1881, the period of our last jubilee, things began to go with a rush. Owens College obtained, in 1880, a charter as Victoria University and could give degrees to its students, and in the early eighties Mason's College, Birmingham, with Poynting as professor of physics, University College, Liverpool, with Lodge as professor, Yorkshire College, Leeds, with Rücker as professor, came into existence and later became universities.

The number of schools where science was taught rapidly increased and as a result of this so did the number of science students coming to the universities. Very clear evidence of this is the fact that in 1881, thirty years after the foundation of the Cambridge natural science tripos, the number of candidates had only risen to twenty-five, while in 1891 the number was ninety-four, practically as great as any other tripos in the university.

It can now, I think, be claimed that some science is taught in all schools, and a good deal in a great many; this is a great advance and has practically all been made in the last fifty years. It can not, however, be said that even now science occupies in our systems of education a place commensurate with its ever-increasing influence on human thought and with its importance in the progress of civilization.

One defect of the present system is that the entrance scholarships offered by most of the great public schools have in practice the effect of attracting the abler boys to classics. In the examination for most of these scholarships much greater weight is given to classics than to any other subject and a boy must have spent most of his time on classics if he is to do well in the examination. Thus, when he goes to the school he is much further advanced in classics than in anything else and, naturally, takes it as his main subject. It may not, however, be the subject in which his strength really lies. For unlike mathematics, in which marked proficiency is only attained by boys with a somewhat rare type of mind, in classics most able boys can under skilful teaching acquire sufficient proficiency to give them a fair chance of getting an entrance scholarship at a public school. These scholarships may thus entice them along a path which does not lead to their true destination. That this actually occurs is, I think, shown by the figures given in the report of the Committee on the Position of Natural Science in the Educational System of Great Britain, 1918. Of the entrance scholarships to Cambridge gained by boys from seven great public schools which give entrance scholarships, for one gained in science, six were gained in classics. This disproportion is far greater than the average for all schools, showing that it is not due to the rarity of scientific talent as compared with classical, but is an artificial one due to the systems in force at these schools.

The last thing I wish to do is to disparage classical studies. I think that for some boys a course in which classics predominates is the best and I think that in the early stages of the education of all boys classics should play a large, perhaps even the largest, part. What I think is desirable is that the school examination should not be so specialized as it is now, and that the papers in classics should not be so much more advanced than those in any other subject.

It is not enough to have introduced physics into schools, it is necessary to develop methods of teaching which will make its study produce its full educational effect. The problem is a difficult one, the teaching of classics and mathematics have long experience and tradition behind them. No such tradition exists for that of physics. The methods have had to be evolved and it can not be said there is yet anything like complete agreement as to which are the best. Science masters are attacking the problem with the greatest vigor and enthusiasm, are trying out one method after another. I think there is perhaps too great a tendency to concentrate on the method to the exclusion of the

personality of the teacher; a good teacher will soon find the method which in his hands gives the best results and will do better with that than with one imposed on him from outside.

POST-GRADUATE STUDY AND RESEARCH

Research is now an integral part of the training of a considerable number of our students and the importance of research for the welfare of the nation universally recognized. This, however, is quite a modern development. It had hardly started sixty years ago and though a vigorous propaganda for the endowment of research was being carried on by Mark Pattison, Huxley, Roscoe, Lockyer and others, it was some time before it began to produce much effect.

Besides the apathy of the country there were at that time three great obstacles to research: (1) The lack of laboratories. We have already seen how this has been remedied. (2) The lack of scholarships to enable men to stay up at the university to research after taking their degree. (3) A third obstacle was that there was hardly any chance of obtaining a livelihood by research alone, so that the only men who made it a career were those who had money or were so enthusiastic that they were reckless about monetary affairs. The case is very different now when research is a recognized profession and a fairly lucrative one.

It is not a great exaggeration to say that in those early days there was neither room, money nor a career for those who wished to research.

Things, however, soon began to mend and research gradually came to be regarded as a suitable subject for the award of scholarships and fellowships. I am glad to say that one of the first, if not the first, to take action in this matter was Trinity College, Cambridge, who in 1874 determined to take into account for election to fellowship any original work which the candidates might submit. Before this the elections had been determined solely on the results of an examination held by the college. They carried out the scheme in no half-hearted way, for at the first election under the scheme in 1874 they elected Francis Balfour, the great zoologist, though it was an open secret that if the examination alone had been taken into consideration another candidate would have been elected. The scheme has been remarkably successful. Many papers of absolute first-rate importance have been submitted by the candidates and now the college has abandoned the examination altogether and only takes into account the original work submitted by the candidates.

In addition to awards for the results of successful research, scholarships began to be founded to enable students who had just taken their degrees to get a post-graduate training in research. The rate of increase in the number of these was very slow in the last century, but this century it has got faster and faster and now grants for training in research are given by most of the colleges, by some of the great city companies, who have done so much for the promotion of science and education, by bodies like the commissioners for the 1851 exhibition, and, above all, by the Department of Scientific and Industrial Research, who have in the last ten years made grants to students in training of £228,970, the average number receiving grants in each year being 184.

In Cambridge the number of students doing post-graduate research increased rapidly after 1895 when a regulation came into force which enabled students who had graduated at other universities to obtain a Cambridge degree after two years' satisfactory research work in Cambridge. This degree was at first the B.A. degree, but in 1920 a new degree, the Ph.D., was instituted by the university for which Cambridge men as well as graduates of other universities are eligible. There are now forty-five of these students in residence taking physics. Of these, by far the greater number hold scholarships or are in receipt of grants. Indeed, I think it can now be said that a really first-class man has an excellent chance of getting, if he is in need of it, sufficient assistance to enable him to get a training in research.

The problem of training a large number of students in research in physics is by no means an easy one; many things have to be taken into consideration and provided for, otherwise the post-graduate course may do more harm than good.

It is very necessary to remember that the importance of the research work done by these students lies not so much in the scientific results obtained as in the training it affords. On this point I should like to read an extract from the report of a commission on the place of science in education, of which I was chairman:

> The training afforded by the study of natural science will be incomplete unless the student undertakes some piece of research in which, relying as far as possible on his own resources, he applies his knowledge of science and of the methods of scientific investigation to the solution of some scientific problem. The effect of a year's work of this kind on the general mental development of the student is most striking. He gains independence of thought, maturity of judgment, self-reliance, his critical powers are strengthened and his enthusiasm for science increased, in fine he is carried from mental adolescence to manhood. We think that whenever possible a year spent mainly on research should form part of the course at the university of those whose work in life will be concerned with the industrial applications of science as well as those who will devote themselves to research and teaching. It is important, however, that at this stage the

teachers at the university should regard research mainly from the point of view of its value as an educational training and not as a means of getting within the year as many new scientific results as possible. The student should be encouraged to overcome his difficulties by his own efforts and the assistance given by the teacher should not be more than is necessary to keep him from being disheartened by failure and to prevent the work from getting on lines which can not lead to success.

I should like to emphasize the last part of this quotation. A year or two spent on research under proper conditions is an educational training which can not easily be overrated, but under others it may be positively harmful. It must always be borne in mind that the primary object of a university laboratory is not the same as that of a laboratory where there are no students in training, such as the National Physical Laboratory or the laboratory of a great firm. In such laboratories the main object is to get results, to discover as many new facts as possible. In a university laboratory the most important thing is to produce well-trained and well-educated men rather than to turn out the largest number of small papers. To get scientific results rapidly, the best plan is for the staff to select the subject for investigation, to determine the kind of experiment to be made, to exercise daily supervision over the work and to leave to the student little besides the taking of the observations. The intellectual development of the student is injured rather than benefited by a training like this. You can not without disaster apply methods of mass production to education. Even in university laboratories where the importance of affording mental training is fully realized, over-specialization is the great danger of these courses of research and one that requires much care to avoid. The student gets so engrossed in his experiments that he grudges the time spent on going to lectures or on reading books which are not on his own special subjects. He often spends too much time in making the experiments and too little in thinking about them. Sometimes, too, he neglects to take advantage of the opportunities afforded by a resident university for social intercourse with men of all shades of opinion and of experience. There is danger, too, of his getting into a groove and to go on working for the rest of his life on the particular subject on which he was first engaged.

I think it helps one to get new ideas if the mind does not dwell too long on one subject without interruption and if every now and then the thread of one's thought is broken. It is, I think, a general experience that new ideas about a subject come when one is not thinking about it. I am not a psychologist and do not know the views held as to how new ideas originate, but to my mind there is considerable practical analogy between this process and one about which we have been hearing a good deal during the last few days, the induction of currents in a magnetic field. For this to occur change as well as the magnetic field is necessary. If a circuit is in such a field nothing happens as long as it is in repose, but if you disturb this repose, currents begin to flow through it. Now compare the circuit to the brain, the magnetic field to the state produced in the brain by long thought about a subject, the starting of a current to the starting of an idea. No ideas will come as long as the brain remains in the same condition without any change in its point of view, but if this changes, then currents or ideas are produced in the brain, the change as it were strikes sparks in the brain. This is one reason why I think it is desirable that the student should do a little teaching, another is that it would give him experience which may be valuable in after-life and help him to obtain a post.

CAREERS AND RESEARCH WORKERS

I now come to the subject of the careers open to men who have had a training in research. Sixty years ago the only posts open to these were teaching posts in the few physical laboratories then in existence. The number of such posts increased very rapidly towards the end of the last century, as did also the demand for science masters for the schools; but until then and indeed for some time after it may be said that roughly speaking the only posts open to research workers were posts associated with teaching. At the beginning of this century, however, the importance of research to our industries began to be realized. The most striking instance of this is the establishment, in 1901, of the National Physical Laboratory for research both in pure science and in subjects which have an immediate application to industry. The growth of this under Sir Richard Glazebrook and Sir Joseph Petavel has been phenomenal; there are now about 160 research workers employed in the laboratory and the budget has increased twenty-fold. Other methods of linking up science with industry are also being employed in this country. Probably the most efficient is for a firm to have its own laboratory where its own problems can be investigated; in this case the inducements for success are greatest and knowledge of the technique and processes involved most accessible.

There are several such laboratories, each with a large staff in this country. They are, however, so expensive as to be beyond the reach of any but very large firms. To extend the benefit of research to the industries generally, the Department of Scientific and Industrial Research was started by the government

in 1915. At the instigation and with the aid of grants from the department, the members of various industries have combined and formed research associations with laboratories suitably equipped for research in matters relating to the particular industry. There are now more than twenty of these associations. They have had to contend with many difficulties; at first there was plenty of money but no well-trained men, now there are plenty of men but no money. There are, however, good reasons for thinking that in spite of these difficulties the financial gain to the industries has far exceeded the expenses of the laboratories. In addition to granting aid to these associations, the department has established boards for research in matters which concern all industries. There is the Fuel Research Board, which deals with problems vital to the country on the production of power from coal and other fuels; there is a Food Research Board, for research on the storage and transport of food; there are boards for building, forest products, radio and chemical research. All these have laboratories and staffs of research workers, as have also the research departments of the army, navy and air services.

I have tried to find how many workers are employed in these applications of science to industry, but have not been able to get any estimate which would be of any value; one great difficulty is to draw the line between posts which seem adequate for those who have gone through a long and expensive training in research and those which do not. One thing, however, can be said, that the demand we have had in Cambridge for workers trained in research has, until this year of acute and long-continued depression, exceeded the supply; and although it is possible to have overproduction in research workers, we do not at present seem to have reached that stage for normal times.

In considering research as a profession, it must be remembered that especially in research of a pioneering kind the worker may spend years without getting results of any very striking importance. He may get depressed, lose hope and be inclined if he gets the chance to go into administration and organization where there is a greater certainty of work yielding an adequate result. The researcher, if he is to have a happy life, must regard the game and not the score as the chief thing. In every research difficulties and apparently anomalous results are constantly turning up. To overcome these, to make clear and consistent what before was obscure and confused, is to some minds one of the keenest of pleasures and one which may be produced by discovering the source of a persistent leak in a discharge tube just as well as by finding a new ray. Experience shows that men with minds of this type are not very common. There are many who when they are young and just fresh from a laboratory, where there is an atmosphere of research and many research workers, are so enthusiastic about research that they think nothing else matters. Often, however, this enthusiasm soon fades and they become more interested in organization and administration than research. Thus, those who begin by working in the research department of a firm tend to drift into the other departments. I think this, on the whole, is an advantage, for it diffuses the scientific spirit and outlook throughout the work of the firm; this may be as important as discoveries in the laboratory and quicker in its effects.

The increase in the number of research workers has naturally led to a corresponding increase in the number of papers on physics. From one point of view this is very gratifying, from another it is embarrassing. *Science Abstracts* for 1930 contains abstracts of 4,165 papers on physics, corresponding to very nearly a dozen a day. It is obvious that no one can read more than a small fraction of these. It is generally more than one can do to read even those in a particular branch of physics, this leads to great specialization. Volumes such as those of *Science Abstracts,* which give the gist of a paper in a small space, are of great value, especially for looking up the literature of a subject over a definite period. For this purpose, however, the subject index is of vital importance; in making this index it is not enough to go by the title of a paper, the contents of a paper can not all be got into its title. The makers of the index should have read the papers. This seems a council of perfection, but it would practically be secured if the maker of the abstract were to send in with it cards for the subject index. This is work that requires great care and sound judgment.

I do not think that abstracts alone are sufficient to cope with this avalanche of papers on physics. As far as I know we have nothing in physics corresponding to the annual reports issued by the Chemical Society on the progress of various branches of chemistry. I think it would be a very good thing if we had, and that it is a thing on which money and time might well be spent. In addition to these, there should, I think, be fuller and more critical reports issued regularly at a longer period, say quinquennially, of the character of those which from time to time have been published by the British Association and by the National Academy of Washington. Another minor suggestion is the publication each month of the titles (without any abstracts) of the physical papers published in scientific periodicals and the proceedings of scientific societies during the preceding month. This used to be a feature of *Wiedemann's Beiblätter* and I found it very useful.

In addition to the advances we have been considering, the instruments and appliances in laboratories are very much better and more convenient than they used to be. The most vivid impression I have of my early work in the laboratory is that of Grove's cells; these had platinum foil immersed in nitric acid for one electrode, zinc in dilute sulphuric for the other, and what with the fumes which assailed one's throat and the acid which destroyed one's clothes, the assemblage of a battery of cells was a most disagreeable business. I have not seen a Grove's cell for forty years and do not want to see another. Now instead of making up a battery we just put a plug into a hole. Another instrument which was exasperating to work with was the old quadrant electrometer; this not infrequently refused to hold its charge and neither prayers nor imprecations would induce it to do so; it has, fortunately, been replaced by more sensitive and convenient instruments. With regard to galvanometers, I have the authority of Mr. Whipple in saying that one suitably selected for the purpose for which it is required may be at least ten thousand times more efficient than the instruments available fifty or sixty years ago. The extensive use of electrical instruments in connection with electrical lighting and engineering has caused a great deal of attention to be paid to their design with the result that they are far more convenient and reliable than they used to be. The improvement of instruments is of first rate importance for the progress of physics, a considerable increase in the efficiency of an instrument may open up a new region of physical phenomena. The most striking example of this is the effect produced by improvements in the methods of producing high vacua. Roughly speaking, we may say that modern physics depends on our power of studying individual atoms and electrons and not merely large crowds of these particles. To do this, one atom must not be hit by another while under observation, as it would make more than ten thousand collisions in a centimeter if the pressure were atmospheric; a very high vacuum is required. Until early in this century this had to be got by Sprengel pumps, which involved one raising and lowering a vessel filled with mercury for hours on end and getting what would now be considered a very poor result, but a vivid appreciation of the intensity with which nature abhors a vacuum. All this was changed after Sir James Dewar introduced the method of producing high vacua by means of charcoal cooled by liquid air. This was not only much more rapid and convenient but produced very much higher vacua and made it possible to make experiments and measurements which could not have been made before the introduction of this method and which have revolutionized our ideas of the structure of matter. If science helps the industries they in return help science. An illustration is that the need of a high vacuum for hot wire valves and electric lamps made its production a matter of commercial importance with the result that the physicist has now at his command pumps so powerful that they can maintain an exceedingly high vacuum in spite of the influx into the vessel of a stream of the particles we wish to study; this is exceedingly important when investigating charged atoms and electrons.

The hot wire valve is another instrument which has greatly helped research in physics; the immense magnification of weak effects which can be produced by it enables us to detect with certainty phenomena which before its introduction were almost beyond our ken. Those who like myself repeated, more than forty years ago, Hertz's experiments will contrast the difficulty we had in detecting electrical waves even when the source was only a few yards away with the ease with which modern methods using hot wire valves detect waves which have traveled thousands of miles.

I have alluded to advances in the efficiency of the instruments. There is another advance in them which is not so gratifying, that is the advance in price. The cost of research in physics is much greater than it used to be. Before the war when about thirty research students were working at the Cavendish Laboratory, the cost of their researches was about £300 per annum. Now it would be at least five times that amount. To balance this there are now far greater sums available for research than there were in those days.

I have in this address confined myself to what may be called the machinery of research in physics. I will now say a word or two about another point. The additions to our knowledge of physical phenomena and to physical conceptions made in the last sixty years have not been excelled by those made in any period of the history of the science, and yet I remember that at the beginning of this period the view was prevalent that all the fundamental principles of physics had been discovered and that the work of the future would be to develop and coordinate those principles and to measure more and more accurately the value of known physical constants. This view seems ludicrous when we know that within a few years Röntgen rays, the electron and radio-activity were discovered. The existence of these was quite unexpected, and no hint of the possibility of their existence was given by any of the physical theories then extant; this view was, however, to my knowledge, held by some eminent physicists. The great generalizations expressed by the first and second laws of thermodynamics loomed so large in those days that it was thought that nothing was beyond their

purview. This state of mind is apt to occur after a great discovery; it occurred after that of universal gravitation; there are signs that it exists now. Yet it has always been falsified by experience, and I think always will be. There are no signs that physics is approaching an asymptotic state in which the progress gets slower and slower as time goes on. The additions to our knowledge of physics made by our generation do not get smaller and smaller as one generation succeeds another, each great discovery is not a terminus but an avenue leading to new knowledge. An improvement in technique may, as we have seen, lead to fundamental changes in our views of the nature of matter and of physical processes. There is far more in physics than is dreamt of in our theories; and nature herself, if we observe her carefully, is more suggestive of ideas than the minds of the most imaginative of us. The ideas which revolutionize science are just those of which our theories give no indications. Theories are the very life-blood of physics. Most of the researches in our laboratories originate in an attempt to test a theory; theory, however, may be injurious if it makes us concentrate our attention exclusively on the particular problem it suggested and to treat as an annoyance, to be avoided by a change in method, any anomaly in the experiment which interferes with our progress to the goal; the anomaly may be the outcrop of a vein rich in new phenomena. After Röntgen had discovered x-rays, another physicist who had been working with somewhat similar apparatus said that he had noticed that any photographic plates near his tube got fogged and spoiled; he moved his plates further away and left it at that. The discovery of argon by Lord Rayleigh arose from some vexatious discrepancies in a series of weighings.

I do not think that there is any danger of the supply of new physical phenomena being exhausted and of physicists joining the ranks of the unemployed. Rather do I believe that as each successive centenary comes round the president of section A will be able to say that the growth of physics in the century which has just passed is comparable with that in any of its predecessors.

POST-EHRLICH IMMUNOLOGY[1]

By Dr. W. H. MANWARING
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FROM a philosophical point of view, classical immunology was equivalent to the postulate that pathogenic microorganisms and the animal body are each vitalized by a unit force, purpose, plan or will that transcends ordinary biochemical laws. Thus supermaterially stabilized, test-tube microorganisms are biochemically identical with the specific infections from which they were isolated and each and every specific serum change in convalescence and artificial immunization is a purposeful defensive hormone. Since this supermaterial somatic organization is immutable in its plan and purpose, it follows that a minute sample of each and every specific serum component that can be formed in the animal body is preexistent in its hereditary tissues, together with a physiological mechanism for its emergency increase in times of specific need. This is but a restatement of the specific receptor hypothesis in non-conventional language.

LOSS OF FAITH IN CLASSICAL THEORY

Recognizing the theological origin of this implied vitalistic theory, and its basic rôle in practical immunology and research, many attempts have been made toward its experimental verification or disproof. Expressed in conventional language, inquiry has been made as to whether or not clinicians are justified in assuming that each and every convalescent serum component is preexistent in normal animal tissues, and whether or not each specific convalescent serum property is a purposeful defensive hormone.

To technical specialists probably the most convincing evidence against this ancestral logic is Otto's alleged separation of "specific sensitizin" from "specific precipitin" by electroosmotic methods. This separation proves that these two convalescent serum components are not chemically identical, and, therefore, can not be mere quantitative variations of the same hereditary defensive hormone.[2] To non-specialists equally suggestive evidence is contained in the war-time researches of Ostromyschlenski and Petroff. These two Russian biochemists incubated mixtures of diphtheria toxin and normal horse serum and found that among the numerous resulting chemical products there are certain denatured serum colloids apparently identical with diphtheria antitoxin.[3] Such test-

[1] Presented before the Society of American Bacteriologists, Pasadena, California, June 18, 1931.

[2] R. Otto and T. Shirakawa, *Ztschr. f. Hyg. u. Infektionskrankh*, 103, 426, 1924.

[3] Ostromyschlenski and Petroff, *Rus. Gesell. f. physical. Chemie*, 47, 263, 1915. (This work was not brought to the attention of international medical science till 1925, and not confirmed in Russian laboratories till 1929, when Kryshanowski prepared several variants of the Ostromy-

tube synthesis would be inconceivable, if diphtheria antitoxin can be formed only as an internal secretion from fixed tissues. Subsequent immunochemists have reported similar test-tube syntheses of specific precipitins, agglutinins and bacteriolysins.[4]

Accumulating evidence of this type has justified the post-Ehrlich denial that each and every convalescent serum change is a desquamated preexistent normal cellular component[5] and has led to the current belief that there are normally present in the animal body enzymic, hormonal and genetic factors capable of synthesizing new or previously non-existent protective specificities.[5,6,7]

Since antitoxins, precipitins, agglutinins, opsonins and other so-called "antibodies" are known or assumed to be specialized proteins, post-Ehrlich immunology assumes that, as a result of natural infection or artificial immunization, new, previously nonexistent protein specificities are synthesized, "induced" or "grafted onto" the animal body, and that some of these exogenous or endogenous "mutant" proteins are specifically defensive in character. This, of course, does not exclude the probability that there are numerous relatively inert "mutant" specificities, and even "induced" specificities injurious to the body.

Recent Advances in Protein Physiology

In approaching problems suggested by this current denial of super-material stabilization and motivation of animal tissues, post-Ehrlich immunologists have to their advantage numerous facts not known to earlier theorists. Probably the most significant of these facts are the recent hints as to the probable nature for protein specificity. Within the last five years, artificial conjugation of a protein molecule with a single amino-acid, lipoid or polysaccharide has been shown to confer upon it a new immunological specificity, the "ongrafted" or "induced" character being to a large extent independent of the nature of its protein carrier. By absorption methods, the conjugated amino-acid, lipoid or polysaccharide can be diagnosed, irrespective of this carrier.[8] The conjugated group may even dominate immunological specificity; egg albumin, for example, conjugated with the complex polysaccharide recently isolated from typed pneumococci, being successful vaccine against experimental pneumococcus infection in rabbits.[9]

Protein specificity, therefore, is no longer regarded as a test of complete protein individuality. It is apparently a composite picture of superficial colloidal "determinants," protein characteristics differing from the composite protein pattern of the animal used for the test. Human proteins, for example, may well be 99 per cent. identical with rabbit proteins, the rabbit precipitin being merely a test for the 1 per cent. human characteristic. Two proteins giving the same serological reaction are no longer necessarily identical. nor are identities revealed by sera or anaphylactic tests with one animal species necessarily the same as relationships revealed by different animal tests. Serological classification of animal and plant proteins is but a classification relative to the animal species selected for the production of the diagnostic antiserum.

Equally significant are the new views as to the probable interrelationship of normal serum colloids. An intravascular conversion of serum albumin into serum globulin is now known to take place, with postulated orderly intravascular syntheses from the simplest nitrogenous compound to the most complex serum colloid. Antigens, therefore, are no longer injected into a static colloidal environment, but into a dynamic protein mixture, with a hundred orderly syntheses and disintegrations, conjugations and dissociations that may conceivably modify their chemical properties.[10]

Older immunologists assumed that absorption of undigested food proteins does not take place through the normal gastro-intestinal mucosa, any apparent absorption being *ipso facto* pathological. Within the last three years, however, it has been definitely proved that gastro-intestinal absorption of undigested food proteins is a normal physiological process[11,12,13] and that alien protein absorption also takes place through other mucous surfaces.[14,15] The normal animal of current immunology is no longer a specific immunological zero, but an animal with a dozen constantly exercised antiprotein functions, a hundred well-developed tolerances or immunities, with the probability that many of these physiological tolerances are directed against minor characteristics of any natural infection or injection antigen.

schlenski artificial diphtheria antitoxin. *Centralb. f. Bakt.*, 110, 1, 1929.)

[4] For bibliography see *Jour. Immunol.*, 19, 155, 1930.

[5] W. H. Manwaring, *Jour. Immunol*, 12, 177, 1926; 19, 155, 1930. (See also, Jordan and Falk, "The New Knowledge of Bacteriology and Immunology," Chap. 81, p. 1,078, 1928.)

[6] A. Locke, E. R. Main and E. F. Hirsch, *Arch. Path.*, 2, 437, 1926.

[7] G. Ramon, *Compt. rend. Soc. biol.*, 102, 381, 1929.

[8] K. Landsteiner and J. van der Scheer, *Jour. Exper. Med.*, 48, 315, 1929; 50, 407, 1929.

[9] O. T. Avery and W. F. Goebel, *Jour. Exper. Med.*, 50, 533, 1929.

[10] J. L. Azevedo, *Proc. Soc. Exper. Biol. and Med.*, 27, 4, 1929.

[11] M. Walzer, *Jour. Immunol.*, 14, 143, 1927.

[12] H. H. Donnally, *Jour. Immunol.*, 19, 15, 1930.

[13] A. Cocoa, *Jour. Immunol.*, 19, 405, 1930.

[14] J. Finder, A. F. Lash and J. Simons, *Proc. Soc. Exper. Biol. and Med.*, 27, 368, 1930.

[15] M. B. Cohen, E. E. Ecker and J. B. Breithart, *Jour. Immunol.*, 18, 419, 1930.

DYNAMIC PROTEIN SPECIFICITY

Classical physiology assumed that the human body is static in its protein specificity. To maintain this stasis it was endowed with a 100 per cent. efficient alien protein excretory function in the kidneys, and a 100 per cent. efficient alien protein destructive function in internal tissues. Current immunology challenges both assumptions. For example, in the albuminurea following excessive protein diet, the urine has been shown to be free from food proteins, apparently containing only normal serum albumins and normal serum globulins, presumably escaping as a result of increased glomerular permeability.[16] Parenteral hydrolysis of alien proteins would be hard to conceive without postulating a multiplicity of highly specialized enzymes, beyond the range of present biochemical knowledge.

There is both direct and indirect experimental evidence that such automatic tissue purification does not take place. It has long been known, for example, that alien proteins injected intravenously into rabbits can not be detected in rabbit tissues later than the fourth day by the ordinary precipitin or anaphylactic tests.[17] This is far from being proof of their quantitative destruction or elimination, however, since a slight change in one or more surface characteristics might conceivably alter the specificity of the injected proteins and thus account for their apparent disappearance. That this is the probable fate of certain alien proteins is shown by injecting horse serum intravenously into dogs and studying its possible retention with specific rabbit precipitin. By the end of six days, the alien serum proteins are so far denatured as to be wholly non-antigenic for dogs, while still retaining part of their original horse protein specificity for rabbits.[18,19] The concentration of these retained, partially "caninized" horse proteins decreases to about 10 per cent. by the end of three months, but with quantitative curves from which their mathematically complete elimination or destruction can not be predicted during the lifetime of the animal.[20]

Indirect evidence in support of such parenteral denaturization and retention may be drawn from recent studies of the so-called "serological ripening" or "physiological maturation," the apparently spontaneous appearances of new serum specificities during adolescence[21] in both man and laboratory animals.[22] So marked is this change in rabbits that old-age rabbit serum injected into younger rabbits is alleged to stimulate the formation of specific precipitins for old-age rabbit proteins.[23] Such new specificities prove retention or environmentally "induced" new specificities, unless one is prepared to postulate a phylogenetic recapitulation of ancestral protein specificities not complete till late adult life.[24]

That such "ongrafting" or "induction" of new specificities is a biological possibility is proved by recent studies of "induced" or "mutant" bacterial specificities; a mixed culture of colon bacilli and dysentery bacilli, for example, with dysentery specificity "grafted" onto the colon bacilli, and persisting for at least seven test-tube generations after separation of the two microorganisms.[25] Probably a more convincing example is the alleged "induction" of diphtheria specificity in associated streptococci, the quasi-diphtheria characteristic persisting for at least twelve test-tube generations after separation of the two microorganisms.[25] Experimentally induced new specificities are also reported in erythrocytes.[26]

The so-called "bacteriophage" furnishes another suggestion example. In time "bacteriophage" may be pictured as a dissociated protein pervert or a dissociated "mutant gene," of slightly different specificity from the parent microorganism.[27] This "mutant" protein is apparently incapable of self-multiplication, but multiplies or is multiplied when absorbed into active symbiosis with intact bacteria.[28] Thus multiplying, it eventually perverts microbic specificity, thus functioning as a lethal factor. For half a century, geneticists have speculated on such possibilities.

PRACTICAL APPLICATIONS

One of the major puzzles of the last two decades has been the numerous inconsistencies and irreconcilabilities in "anaphylaxis" and immunity.[29] To the newer immunology "sensitivity" is due to accelerated humoral and cellular reactivity, with no preconception as to whether or not such acceleration acts to the specific advantage or disadvantage of the individual.[30,31,32]

[16] H. G. Wells, *J. A. M. A.*, 53, 863, 1909.
[17] R. M. Pearce, *Jour. Exper. Med.*, 16, 349, 1912.
[18] W. H. Manwaring, H. D. Marino, T. C. McCleave and T. H. Boone, *Jour. Immunol.*, 13, 357, 1927.
[19] W. H. Manwaring, H. D. Marino and J. L. Azevedo, *Jour. Immunol.*, 15, 109, 1928.
[20] H. C. Sox and W. H. Manwaring, *Jour. Immunol.* (in press).
[21] E. Friedberger, G. Bock and A. Furstenheim, *Ztschr. f. Immunitätsforsch.*, 68, 480, 1930.
[22] E. Friedberger and D. Gajzago *Ztschr. f. Immunitätsforsch.*, 67, 67, 1930.
[23] T. C. Picado, *Compt. rend. Soc. biol.*, 102, 631, 1929.
[24] Editorial, *J. A. M. A.*, 96, 950, 1931.
[25] G. W. Wygodtschikoff and N. S. Mannilowa, *Ztschr. f. Immunitätsforsch.*, 68, 480, 1930.
[26] C. Hallauer, *Ztschr. f. Immunitätsforsch.*, 67, 15, 1930.
[27] C. W. Jungeblut and E. W. Schultz, *Jour. Exper. Med.*, 69, 127, 1929.
[28] A. P. Krueger and J. H. Northrop, *J. Gen. Physiol.*, 14, 223, 1930.
[29] A. R. Rich, *Arch. Path.*, 7, 552, 1929.
[30] W. H. Manwaring, H. D. Marino, T. C. McCleave and T. H. Boone, *Jour. Immunol.*, 13, 357, 1927.
[31] W. H. Manwaring, H. D. Marino, J. L. Azevedo and H. C. Torbet, *Jour. Immunol.*, 15, 351, 1928.

While classical vaccine therapy and serum therapy were justly proud of their few spectacular victories, they were humiliated by wholly illogical and much more numerous clinical failures. To post-Ehrlich immunology, test-tube "mutants" are not necessarily specific immunizing agents against corresponding infections, nor are serum "antibodies" in the horse necessarily directed against the antigenic "determinants," pathogenic for man.

Recent studies have shown that pathogenic microorganisms not only multiply in the corresponding specific immune serum but often multiply much more rapidly than in control tubes with normal serum.[33] A specific growth-stimulating bacterial retention product in convalescent animals is no paradox to modern theorists.

Recent tests have shown that tuberculous animals are not only resistant to superinfection with tubercle bacilli, but are apparently equally resistant to influenza, anthrax, streptococci and diphtheria toxin.[34] If in time it should be shown that there is no appreciable specific protective factor in tuberculosis, that the increased resistance to superinfection is largely nonspecific, it will be no surprise to current theorists.

Classical immunology is to-day puzzled by the apparently spontaneous appearance of diphtheria immunity in adolescent Eskimo children in an environment demonstrably free from diphtheria bacilli.[35] Post-Ehrlich immunology is prepared to consider a phylogenetic recapitulation of ancestral immunity not necessitating personal contact with specific infections.[36]

SUMMARY

Future bacteriologists can not assume without convincing experimental evidence that any pathogenic microorganism is necessarily static in its biochemical specificity, but must consider the possibility that immunochemical specificity varies with test-tube conditions, animal species, organ or tissue infected and stage of infection.

Future serologists can not assume without convincing experimental evidence that any specific serum component or property is necessarily a specific "antibody" or "defensive hormone"; but must consider the possibility of a wide range of "ongrafted," "induced" or "mutant" specificities, with no preconception as to their probable immunological rôle.

Future immunologists can not assume that the formation or "induction" of new protein specificities is the only important adaptive factor in specific immunization; but must emphasize the relative importance of collateral hypertrophies of non-specific enzymic, hormonal and genetic factors.

Finally, future clinicians must be cautious in endorsing any infectious theory which assumes or implies that the animal body is static in its biochemical specificity; but must be receptive of the accumulating evidence that specificity varies in different tissues, organs and body fluids, and at different stages of anatomical and physiological growth.

[32] A. Besredka, "Le choc anaphylactique," Masson et Cie, Paris, 1930, Chap. 7, p. 263, *et seq.*

[33] M. Nocolle and E. Cesari, *Annal. d. Inst. Pasteur*, 40, 43, 1926.

[34] T. Hirayama, *Ztschr. f. Immunitätsforsch.*, 68, 218, 1930.

[35] Bay-Smith, *Klin. Wochenschr.*, 21, 947, 1929.

[36] Editorial, *J. A. M. A.*, 96, 950, 1931.

OBITUARY

DAVID STARR JORDAN

DAVID STARR JORDAN was born on a farm near Gainesville, Wyoming County, New York, on January 19, 1851. He died at his home, Serra House, on the campus, Stanford University, California, at 9:45 o'clock on Saturday morning, September 19, 1931, at the ripe age of 80 years and eight months.

On July 3, 1929, Dr. Jordan became very seriously ill, due in large part to the unusual extreme heat which prevailed during the first few days of that month at Stanford. For some time he was confined to his bed and his life was despaired of, but, in spite of renewed attacks, he recovered from each to some extent, but never quite fully; each relapse left him a little weaker than before. During these periods of partial recovery he was able to be taken in a wheel-chair out into his flower garden, where he would remain some time each day in comfort in the pleasant surroundings. On one or two occasions he was taken to the quadrangle and to various places about the campus so familiar to him during his long connection with the university. The last of these little visits to old familiar scenes was only a few days before the end came.

Until toward the last he retained his interest in world affairs, and in certain ichthyological studies upon which he was engaged when first stricken. His last considerable contribution to ichthyological literature is a "Check-List of the Fishes of North and Middle America," a volume of 670 pages, the manuscript of which was finished only shortly before what he jokingly referred to as his "unceremonious collapse." He was pleased when the "Check-List" appeared in print (February 8, 1930), and he autographed three copies on March 27.

I first met Dr. Jordan in the spring of 1877 at

Butler University, where he then was professor of biology. The next year I was one of a dozen students led by Professor Jordan on a walking trip of 550 miles through the South—from Somerset, Kentucky, across Kentucky, Tennessee and North Carolina, into northern Georgia. This was, in fact, a traveling school. Dr. Jordan had been through that country before and, being quite familiar with it, he gave us at least one lecture each day on the geology, natural history or political history of the region through which we were passing.

That tramp through the South with Dr. Jordan was the most important influence that ever came into my life. I came to know him intimately and from many angles, and my admiration for his scholarly attainments and for him as a man grew day by day. I then and there determined to continue as a student of his so that I might get as much from his inspiring teaching as possible. That I did, and the association and the personal friendship begun then continued without interruption and without a single jar to the end, I always as his humble and enthusiastic helper, proud of his friendship and grateful for his patience and encouragement.

Dr. Jordan was, first of all, a naturalist. His intimate knowledge of many species of animals and plants, gained through observation and study in the field of many individual animals and plants themselves, was marvelous. In the making of a naturalist and the study of systematic zoology and botany, he regarded books as of value but as of only secondary importance. He often said (quoting Agassiz) "when one studies Nature from books alone, he will not know her when he meets her in the woods or fields." He was amused by the discussion of evolution and the origin of species, in the papers at the time of the Scopes trial. He felt that the only way in which species can be studied understandingly is through a careful examination and comparison of numerous specimens of different and related species. Reading books about animals and plants can not alone give any clear conception of what a species is. And one can not very clearly understand what is meant by the organic evolution of species unless he compares many specimens of closely related species. Books about animals can not lead; a study of the animals themselves must come first. Dr. Jordan was a real naturalist. He knew the animals and plants of the old farm on which he was brought up, and those of every region in which he later lived; not only the fishes (his first and abiding interest), but the birds, mammals, reptiles, amphibians, mollusks, crustaceans, lichens and the algae not only of the fresh waters and damp places but of the sea as well.

Dr. Jordan was a great teacher; great, whether the subject be geology, botany, entomology, invertebrate marine zoology, ornithology, ichthyology, general biology or evolution; or the languages, as German, French or Norwegian; for he, at times, had classes in every one of these subjects—and I was in most of them. In the laboratory, after a few general directions, he usually left the student to his own resources, only asking him a few questions now and then, and checking up on his work. He would very early assign some particular problem to the student. If the student showed any special ability, Dr. Jordan would suggest that he prepare a paper on the subject for publication. Frequently he would ask the student to join him in the study of some group of fishes or collection of fishes upon which he (Dr. Jordan) was engaged. He would frequently ask the student to be junior author with him of the paper. Dr. Jordan has thus had associated with him more young men and women as junior author than any other writer whose name I now recall. He thoroughly believed in the dictum of the late Colonel Francis W. Parker, that "we learn to do by doing. If you wish to learn to write reports of your researches, try your hand at it." Dr. Jordan was an inspiring teacher. The subjects he taught were usually elective, but the number of students that elected work with him was a good proportion of the whole. In the graduating class at Indiana University in 1886 there were twenty-one members (Iowa University was small in those days), but of these twenty-one, five mastered in zoology; four of the five in ichthyology, and four of the five became professional zoologists. One of the best ways to measure the greatness of a teacher is to consider what becomes of his special students.

As an educator Dr. Jordan was no less great. His influence upon educational theory and practice has been profound. Even while yet at Butler College he had begun to advocate the giving of greater freedom to the student in the selection of the subjects that should be required for graduation. When he went to Indiana University in 1879 he continued to speak for greater elasticity in the curriculum. When he became president of Indiana University in 1885, he at once began to put the elective system into effect. He believed that the natural and physical sciences and modern languages are no less valuable than mathematics and the dead languages for mind development and training, and that their cultural value should be recognized. Under this system the student's major professor becomes his counselor and guide. With the opening of Stanford University in 1891 with Dr. Jordan as its first president, then the really great opportunity came and Dr. Jordan embraced it with all his wonderful power and enthusiasm. With a faculty of his own selection of able young men with un-

bounded enthusiasm and an institution unhampered by tradition, the time was auspicious for a great adventure in higher education. It was made; and what was largely educational heresy then is now accepted throughout America. Under Dr. Jordan's influence the natural sciences became respectable parts of the college curriculum.

Although Dr. Jordan was deeply interested in all branches of natural history, his special field was ichthyology. His first paper, however, appears to have been botanical, on "The Colors of Vegetation," published in 1873, and his next, published the same year, was on "Hoof-rot in Sheep," both no doubt resulting from his observations on the old farm where he was born and reared. In 1874 he published in the *American Naturalist* two botanical papers, and the next year he published, also in the *American Naturalist*, his first contribution to ichthyological literature, "The Sisco of Lake Tippecanoe." He described the sisco as a new species under the name of *Argyrosomus Sisco* Jordan. This was the first new species of fish ever described by Dr. Jordan. Since that year Dr. Jordan collected fishes in many waters in many parts of the world, and he described and named nearly a thousand new species and about five hundred new genera of fishes. For more than twenty years he was the most active ichthyologist in the world, and for more than thirty years he was the most distinguished student of fishes in the world.

In his study of fishes Dr. Jordan was interested in finding out what different kinds or species are found in different waters, and the relationship between those of one stream to those of other streams. To interpret the problems of geographic distribution it is necessary to know the species involved; hence careful comparison, study of differences and resemblances, is necessary; in short, to understand the origin of species it is necessary to know what the species are. Dr. Jordan did not limit his study of species of fishes to an examination of research collections; he was one of the keenest, most observing of field naturalists; he "knew fishes when he met them in their native waters" and was interested in their ecological relations.

A complete bibliography of Dr. Jordan's papers and books on fishes is not at hand, but it contains more than 450 titles. These contributions varied in size from a few pages to one of 3,528 pages and 392 plates.

Dr. Jordan once said: "I have lived three more or less independent lives: first, and for the love of it, that of naturalist and explorer; second, also for the love of it, that of teacher; and third, from a sense of duty, that of minor prophet of Democracy." And he adds that "if he had his days to live over, he would again choose all of the three." And each of these lives, filled with life's enthusiasms and faith in the final triumph of truth and righteousness in the world, he lived joyously.

For David Starr Jordan was a man who enjoyed life and who gloried in the opportunities that came to him to use his tremendous mental and physical strength for the good of his fellow man. His power of memory was astounding, his knowledge profound. He was an inspiring teacher, kind, sympathetic, utterly unselfish, and always ready to give encouragement to any student who seemed to need it.

Dr. Jordan was very unassuming and of marked simplicity; to his intimate associates, he seemed always a big brother, a big overgrown boy, big in body and in mind, but, withal, a boy. We were not always sure whether to take him seriously. I rarely or never saw him "lose his head," or become openly angry. In spite of frequent display of wit and humor, he was always dignified and in a big way; we never "slapped him on the back," nor called him by his first name. His humorous and witty expressions and his pithy aphorisms were wonderfully helpful in his teaching. On one occasion a bright but convivial young man applied for a certain position with which Dr. Jordan was concerned. Dr. Jordan, in telling us about it, said: "The job is too big for a boozer. We can't run our plant on cocktail power and cigarette smoke."

I can do no better than to close this notice with the felicitous words written by President Herbert Hoover as the dedication to David Starr Jordan of "The Stanford Quad" for the collegiate year 1929–30:

> First president of our beloved university, creator of its oldest traditions, scientist of unquenchable thirst for truth and of unalterable integrity in its search, teacher of sympathy and imagination, friend of youth, wise counselor, believer in the inviolable sanctity and worth of the individual human soul, exemplar of the moral virtues, inspirer to the spiritual life, apostle and prophet of peace, this book is dedicated with veneration, devotion, and affection.

BARTON WARREN EVERMANN

MEMORIALS

THE suggestion has been made that a statue of the late Dr. Stephen Moulton Babcock be erected in recognition of his generosity in giving his test for butter fat in milk to the public as well as of the many other contributions to dairy science which he made. It is felt that a fund of approximately $30,000 should be raised to insure a statue and setting worthy of the purpose and the donors. The Babcock statue fund will serve as a token of appreciation from those of his generation who contribute to it and as an incentive

to future generations to stimulate them to future good deeds. Contributions to the fund are now in order and may be sent to the treasurer, Professor E. H. Farrington, University of Wisconsin, Madison, Wisconsin.

RECENT DEATHS

DR. JAMES W. GIDLEY, assistant curator of fossil mammals in the U. S. National Museum, died on September 26, at the age of sixty-five years.

DR. GEORGE THOMAS ELLIOT, emeritus professor of dermatology at Cornell University Medical School, died on September 14, aged seventy-five years.

DR. HARRY PHILLIPS DAVIS, vice-president and director of the Westinghouse Electric and Manufacturing Company and chairman of the National Broadcasting Company, died on September 10, at the age of sixty-three years.

DR. JOHN B. DEAVER, emeritus professor of surgery and formerly head of the department in the school of medicine of the University of Pennsylvania, died on September 25, in his seventy-sixth year.

ARTHUR KENDRICK, formerly associate professor of physics at the Rose Polytechnic Institute and president of the International Equipment Company, died on September 23, aged sixty-six years.

WILLIAM A. TITUS, assistant technical superintendent of the Western Electric plant at Chicago, died on September 19. He was fifty-one years old.

DR. WILLIAM A. EWING, well-known surgeon and past president of the Dayton Academy of Medicine, died on September 17. Dr. Ewing was in his fifty-fifth year.

DR. ANDREWS A. CAIRNS, director of the Municipal Department of Health in Philadelphia, died on September 9, aged sixty-seven years.

DR. STEWART LEROY MCCURDY, organizer of the Pittsburgh Dental College, now the dental school at the University of Pittsburgh, died on September 8 at the age of 72. He had been an instructor in the school since 1896.

MR. DONALD FAIRFAX WHITING, an electrical engineer with the Fox Films, Inc., who was forty years of age, was killed on September 7 by falling from a tree.

DR. SAMUEL H. CHAPMAN, member of the advisory board of the department of archeology at the University of Pennsylvania, died on September 22, in his seventy-fifth year.

SIR WILLIAM J. R. SIMPSON, director of tropical hygiene at the Ross Institute at Putney, England, died on September 20. He was seventy-six years old.

MR. MATTHEW MONCRIEFF PATTISON MUIR, senior fellow of Gonville and Caius College, Cambridge, formerly praelector in chemistry at Caius College, died on September 2, aged eighty-two years.

MR. DAVID DAVIES, well-known English paleobotanist, died on August 15 at the age of sixty-one years.

MISS JOAN B. PROCTER, curator of reptiles at the London Zoological Gardens, died on September 20, after a long illness. She was thirty-four years old.

SCIENTIFIC EVENTS

THE INTERNATIONAL ILLUMINATION CONGRESS

THE International Illumination Congress opened on September 1, when Mr. C. C. Paterson, the president, and others prominently associated with illuminating engineering and the lighting industry were present at the reception bureau at London University in order to greet delegates from all countries. Although the original estimate of the attendance was in the neighborhood of 400, there were over 500 names on the official list when the congress opened. According to the *Electrical Review*, something like twenty different countries were represented.

The program in London from September 1 to 3 was mainly social. It included facilities for visiting the E. L. M. A. Lighting Service Bureau, the General Electric Company research laboratories at Wembley, the National Physical Laboratory, and other institutions of special interest in connection with lighting, as well as places of national and historic interest.

The proceedings included a luncheon on September 1 at the Savoy Hotel, given by the Gas Light and Coke Company and the London electricity supply undertakings, at which the toast of "The International Illumination Congress" was proposed by Mr. George Lansbury, who, on behalf of H. M. Office of Works, had taken a very sympathetic interest in the work of the congress and the floodlighting arrangements. An address of welcome was also delivered in English, French and German by Lieutenant-Colonel Kenelm Edgcumbe, chairman of the general council of the congress, who presided, and M. A. Filliol, of Switzerland, honorable treasurer of the International Commission on Illumination replied in English and French on behalf of the foreign delegates.

Following the luncheon there came what was un-

doubtedly the chief item of the London entertainments, namely, a river tour starting from Waterloo Bridge at 2:30 P. M., visiting Greenwich and returning by the Tower of London and Westminster by 10:30 P. M. This trip afforded an excellent opportunity of seeing the floodlighted buildings, which were visible from the river, and of witnessing the performances of *H. M. S. President* off the Embankment, *H. M. S. Scout* in the Pool of London, and the illuminated fire-floats off Hungerford Bridge. From 10:30 P. M. onwards a motor tour for the purpose of viewing other floodlighting installations, not visible from the River Thames, including the display of floodlighting with gas in St. James' Park and the super-illumination of Whitehall, had been arranged.

During the evening of the second day of the congress a banquet was arranged at the Dorchester Hotel, London, when the toast of "The International Illumination Congress" was proposed by Sir Hugo Hirst, chairman of the General Electric Company, Ltd., supported by Mr. Henry Woodall, deputy governor of the Gas Light and Coke Co.; speeches were delivered by Professor E. C. Crittenden, of the United States; M. A. Filliol, of Switzerland, and Herr E. Wissmann, of Germany, on behalf of the foreign delegates. Following the banquet a motor tour of London's streets was planned for some of the guests.

Following the congress more technical questions will be dealt with during the International Commission sessions at the University of Cambridge. On September 3 the congress moved on from London to Glasgow, and in due course, Edinburgh, Buxton, Sheffield and Birmingham were visited, prior to the session of the International Commission on Illumination, which took place in Cambridge from September 13 to 19.

COMMITTEE APPOINTMENTS OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

AT the August meeting of the board of directors of the American Institute of Electrical Engineers, President Skinner announced the committee appointments for the administrative year beginning August 1, 1931. The chairmen of the general committees are as follows:

Board of Examiners: H. Goodwin, Jr., consulting engineer, Philadelphia, Pa.

Finance: C. E. Stephens, vice-president and northeastern district manager, Westinghouse Electric and Mfg. Company, New York, N. Y.

Publication: E. B. Meyer, vice-president, United Engineers and Constructors, Inc., Newark, N. J.

Meetings and Papers: W. H. Harrison, plant engineer, American Telephone and Telegraph Company, New York, N. Y.

Sections: Everett S. Lee, general engineering laboratory, General Electric Company, Schenectady, N. Y.

Membership: R. L. Kirk, assistant to the vice-president, Duquesne Light Company, Pittsburgh, Pa.

Law: W. S. Gorsuch, engineer of economics, Interborough Rapid Transit Company, New York, N. Y.

Coordination of Institute Activities: H. P. Charlesworth, vice-president, Bell Telephone Laboratories, New York, N. Y.

Student Branches: W. H. Timbie, professor of electrical engineering and industrial practice, Massachusetts Institute of Technology, Cambridge, Mass.

Headquarters: R. H. Tapscott, electrical engineer, New York Edison Company, New York, N. Y.

Public Policy: B. Gherardi, vice-president and chief engineer, American Telephone and Telegraph Company, New York, N. Y.

Standards: A. M. MacCutcheon, engineering vice-president, Reliance Electric and Engineering Company, Cleveland, Ohio.

Edison Medal: D. C. Jackson, head of the department of electrical engineering, Massachusetts Institute of Technology, Cambridge, Mass.

Lamme Medal: C. C. Chesney, honorary vice-president, Pittsfield Works, General Electric Company, Pittsfield, Mass.

Code of Principles of Professional Conduct: R. F. Schuchardt, chief electrical engineer, Commonwealth Edison Company, Chicago, Ill.

Award of Institute Prizes: W. H. Harrison, plant engineer, American Telephone and Telegraph Company, New York, N. Y.

Safety Codes: J. C. Forsyth, supervising engineer, New York Board of Fire Underwriters, New York, N. Y.

Columbia University Scholarships: W. I. Slichter, professor of electrical engineering, Columbia University, New York, N. Y.

Legislation Affecting the Engineering Profession: H. A. Kidder, Superintendent of Motive Power, Interborough Rapid Transit Company, New York, N. Y.

Economic Status of the Engineer: C. O. Bickelhaupt, assistant vice-president, American Telephone and Telegraph Company, New York, N. Y.

Advisory Committee to the Museum of Science and Industry in the City of New York: John Price Jackson, manager, department of personnel and statistics, Manhattan district, New York Edison Company, New York, N. Y.

WILD LIFE IN NATIONAL FORESTS

A CONTINUOUS yield of fish and game for the woods and streams in the national forests, with replenishment each season, like the repetition of field crops is the ideal of the U. S. Forest Service, according to the chief forester, Mr. R. Y. Stuart. Mr. Stuart states that the total production of fish and wild life of the country is inadequate to meet the ever-increasing demand for outdoor recreation and that the Forest Service aims to restore and develop recreational and fishing opportunities.

The national forest program is fitting itself into public plans and the Forest Service is ready to cooperate in any sound national game program.

The continuous yield of fish and game as a practical working principle is gaining ground. That certain species are almost extinct on some areas, that there is a satisfactory breeding stock with inadequate increase on other areas, while still other areas are overpopulated, clearly indicates the need of applying the principle on national forests. All land and water are capable of producing some species of fish or game or fowl or fur-bearing animals, or a combination of them, beneficial to mankind.

In reference to game refuges and stocked streams, he says, it is immaterial whether state or federal agencies take the responsibilities for their regulation and productivity, so long as such areas are administered effectively. A total of 267 state game refuges, including more than 20,000,000 acres, has been established on national forest land. These areas are administered jointly by the states and the Forest Service. In a few cases refuges have already developed an overpopulation of wild game. But generally a maximum of fish in the streams and lakes can only be obtained by hatching and releasing many millions of fish of the proper size.

To give the game and fish a fair opportunity it is necessary to protect the refuges from unlawful hunters and fishers, predatory animals, parasites, and also from forest fires. Fires are as fatal to fish as to animals. Loss follows from unregulated streamflow, mud, poisoning by ashes and destruction of natural food through a combination of these conditions.

The growth of public sentiment against fire has been of great help, and last year, for the first time in history, forest fires in the national forests of the United States were kept down to a safe minimum.

At this time stream surveys are being made in national forests to determine the fish-carrying capacity of the streams, the adaptability of streams to various species, and to prevent duplication of effort. The Bureau of Fisheries and the state game and fish commissions are cooperating in gathering this information.

THE NEW AGRICULTURAL ENGINEERING BUILDING AT THE UNIVERSITY OF KENTUCKY

THE new $75,000 agricultural engineering building completed recently on the experiment station farm of the University of Kentucky is now occupied by members of the faculty, and the shops, laboratories and classrooms are being equipped for school work during the present semester. The building is of Southern colonial architecture, built of concrete and brick, and is fireproof throughout. The main part consists of two stories and basement, and the one-story wings form a U-enclosure for a machinery court in the rear. The structure is 198 feet across the front and 98 feet deep.

The basement houses drainage, sanitation equipment and concrete work laboratories and storage room for lumber, supplies and machinery. The first floor is given over to laboratories for farm motors, tractors, machinery, buildings, shops, experimental work, the crops drying and storage rooms, tool and recitation rooms. On the second floor are offices, drafting and blue-printing rooms and classrooms.

Manufacturers and dealers in farm equipment are cooperating by lending machinery and other equipment for the new building, including motors, tractors, pumps, sanitary equipment, rural electrical equipment, barn and other building materials, and practically every type of field machinery used in Kentucky. This equipment will be kept up to date, in order that students and visitors may see the latest types of farm machines and other equipment.

The agricultural engineering department is allied with the agronomy department of the experiment station and college of agriculture for administrative purposes. The personnel of the department consists of Professor J. B. Kelley, professor of agricultural engineering, who is in charge; Earl G. Welch, extension agricultural engineer, and Howard Matson, part-time instructor and part-time extension engineer. Courses are offered to college students covering the various phases of agricultural engineering, such as farm motors, farm buildings, farm machinery, sanitation equipment, rural electrification, farm drainage and the prevention of soil erosion.

THE PUBLICATION OF NEWTON'S CORRESPONDENCE

THE fact that no edition of Newton's correspondence is available, which has constituted sometimes a surprise for the "honnête homme," is always a terrible handicap to the scientist, to the scholar and especially to the historian of science. Even with the help of the biographies and bibliographies of Edleston, Brewster, Gray and Zeitlinger, which are not always complete, one is too often vexed because the letters of the illustrious Englishman are sometimes practically lost in almost inaccessible works or collections and also because a great number of them—without which one may not hope to describe with precision the evolution of Newton's thought—are still missing, simply owing to the fact that no systematic attempt to collect them has ever been made. The relative ease with which several of them have been traced in recent years proves this last point.

In a letter published in *Nature* a few years ago, Sir Joseph Larmor has recalled how a project devel-

oped in the beginning of this century at Cambridge for an edition of Newton's works failed: " . . . As time passed it became clear, to me at any rate, that a committee of editors could not be very effective, especially when it consisted of men primarily intent each on his own scientific pursuits. Thus no effort has since been made to push the project. . . . But one may be permitted to express the view that a systematic collection of the letters remains most desirable, and the hope that some day that part of the scheme may be realized." It may be recalled that even the hope to form in England a Newton Society has been given up, too, according to the late Professor H. H. Turner.

A comprehensive and critical edition of Newton's correspondence must, of course, include all the memoirs written under the form of letters to Oldenburg, and published in the *Philosophical Transactions,* very often with alterations and omissions, the letters by Newton's correspondents, extracts from the letters of contemporaries which concern him, and his own letters, of which those now known number something less than 250. The Adam-Tannery edition of Descartes' correspondence is perhaps the best model to be followed. The realization of this project would no doubt constitute by far the most important contribution to the celebration in 1942 of the tricentenary of the birth of Newton.

SCIENTIFIC NOTES AND NEWS

PLANS have been completed by the Association of Illinois Chemists for having portraits painted of Professor A. W. Palmer, who was head of the chemistry department at the University of Illinois from 1894 to 1904, Professor W. A. Noyes, director of the chemical laboratory from 1906 to 1926, and Professor S. W. Parr, in charge of applied chemistry from 1894 to 1926. These men stand out, not only as leaders among American chemists, but also as the individuals who have done most to develop a successful chemistry department at the university. The portraits will be hung in the Chemical Library as an inspiration to all the younger students in chemistry. Dr. N. W. Krase is secretary of the committee.

MR. PHILIP DRINKER, assistant professor of ventilation and illumination in the school of public health of Harvard University, and Louis Agassiz Shaw, also of the school of public health, have been awarded the John Scott Medal for the invention of the Drinker respirator. Presentation of the medals will be made in the hall of the Franklin Institute on November 12.

IN celebration of Dr. Walter Bradford Cannon's twenty-five years as George Higginson professor of physiology in Harvard University, the afternoon and evening of October 15 have been set aside for exercises befitting the occasion, at the Amphitheater, Building C, Harvard Medical School, at 4 P. M., with Dr. David L. Edsall presiding. Papers will be given by Dr. Walter C. Alvarez, of the Mayo Clinic, on "Influence of Dr. Cannon's Work upon Medical Thought and Progress" and by Dr. William H. Howell, of the Johns Hopkins School of Hygiene, on "The Development of Physiology during the Past Twenty-five Years, and Dr. Cannon's Influence upon It." At 7:30 P. M. a dinner will be given at the Vanderbilt Hall Gymnasium, at which President Lowell will preside. Dr. Graham Lusk, professor of physiology of the School of Medicine of Cornell University, will speak on "The Life of a Professor." The presentation to the medical school of the portrait of Dr. Cannon will then take place. The committee in charge are: Dr. Henry A. Christian, *chairman,* Dr. Harvey Cushing, Dr. Alexander Forbes, Dr. Alfred C. Redfield and Dr. Cecil K. Drinker.

SIR HUBERT WILKINS, well-known Arctic explorer, was presented with a gold medal and diploma of the Italian Royal Geographical Society on July 23 on board the *Nautilus,* in recognition of his services to science in connection with polar research work.

THE American Astronomical Society has elected the following new officers besides the president, Dr. W. S. Adams, whose election was announced in SCIENCE last week: *vice-president,* Dr. C. G. Abbot, director of the Astrophysics Observatory of the Smithsonian Institution; *councillors,* J. C. Hammond, astronomer at the U. S. Naval Observatory, P. W. Merrill, astronomer at the Mt. Wilson Observatory, and H. H. Plaskett, director of the Dominion Observatory of Canada. Benjamin Boss, director of the Dudley Observatory, was reelected treasurer, and R. S. Dugan, professor of astronomy at Princeton University.

DR. ISAIAH BOWMAN, of New York, director of the American Geographical Society, has been elected president of the International Geographical Union at its closing session in the University of Paris on September 24. The next meeting of the union will be held in Warsaw in 1934. General Robert Bourgeois, of France, was elected first vice-president. General Vaccheli, of the Military Geographical Institute at Florence; Professor E. Romer, of the University of Lvov, Poland; Brigadier Harold Winterbotham, director-general of the Ordnance Survey of Great Britain; Professor Nunez, of Spain, and Sir Ahmed Mohamed, of Egypt, were elected second

vice-presidents. The congress was attended by more than 800 delegates from thirty-four nations, including fifty delegates from the United States. The meeting closed on the evening of September 24 after a banquet was given to the leaders of the delegations and a reception to delegates.

DR. JAY F. SCHAMBERG, professor of dermatology and syphilology in the Graduate School of Medicine at the University of Pennsylvania and director of the Dermatological Research Institute in Philadelphia, was installed as president of the Philadelphia County Medical Society on September 23. He gave the presidential address of acceptance, and an oration was delivered by the retiring president, Dr. George P. Muller, professor of clinical surgery in the medical school of the University of Pennsylvania. Other officers installed were: Dr. Charles F. Nassau, clinical professor of surgery at Jefferson Medical College, as president-elect; Dr. W. Burrill Odenatt, vice-president; Dr. Henry G. Munson, secretary, and Dr. R. Powers Wilkinson, treasurer. Associate vice-presidents who take office are Dr. L. C. Hamblock, Dr. C. Fisher, Dr. E. Paul Reiff, Dr. William H. Chandlee, Dr. Francis V. Gowan and Dr. Samuel Cohen. Dr. George C. Yeager, recently elected vice-president of the American Medical Association, Dr. Francis Ashley Faught and Dr. Nathan Blumberg are the newly elected members of the board of directors.

DR. ARTHUR W. GOODSPEED, professor of physics in the college at the University of Pennsylvania and director of the Randal Morgan Laboratory of Physics, has retired at the age of seventy-one years. Dr. Goodspeed has been connected with the university since 1884. Other retirements include Dr. Albert E. Roussel, professor of medicine, and Dr. James E. Talley, professor of cardiology.

DR. J. PAUL VISSCHER has been appointed professor and head of the biology department at Western Reserve University.

DR. DOUGLAS R. DRURY, of Harvard University and associate physician at the Huntington Memorial Hospital in Boston, has been made professor of physiology at the University of Southern California.

AT Lafayette College, John H. Wilson has been made professor of chemistry, and Professor Paul B. Eaton head of the department of mechanical engineering. Those advanced to the rank of associate professor are: James H. DeLong, in chemistry; Harry A. Itter, in geology, and Ernest M. Fernald, in mechanical engineering. Instructors promoted to the rank of assistant professors are: Charles K. Cabeen, in geology; William Beverly, in mathematics; Charles M. Merrick, in mechanical engineering. The following instructors have been appointed: Robert J. Crosen, in chemistry; Charles T. Brown, in physics; Harry L. Anthony, in mining engineering, and Paul P. Price, in civil engineering.

THE Pennsylvania State College has announced the appointment of the following department heads: Professor H. A. Everett, professor of thermodynamics, to be head of the department of mechanical engineering; Dr. Harry B. Northrup, formerly acting head of the department of metallurgy, to be head of the extension division of the school of mineral industries; Dr. Albert W. Gauger, formerly head of mines and mining experiments at the University of North Dakota, to be director of mineral industries research and professor of fuel technology.

ADDITIONS to the faculty of George Washington University include: Dr. L. Edwin Yocum, assistant professor of botany; Dr. Albert Spear Hitchcock, professorial lecturer in botany; Dr. Herman Henry Kaveler, instructor in chemistry, and Paul Hugh Emmett, lecturer in chemistry. In the school of medicine, Lieutenant Commander Franklin Forman Murdoch, acting executive officer of the Naval Medical School, will become professor of tropical medicine, and Myron C. Waddell has been appointed instructor in anatomy.

DR. J. C. GEIGER, professor of epidemiology of the George Williams Hooper Foundation for Medical Research and the University of California Medical School, San Francisco, has been appointed health officer of the city and county of San Francisco, filling the vacancy created by the sudden death of Dr. William C. Hassler.

DR. JOHN M. NOKES, formerly of Nashville, Tennessee, has been appointed assistant professor of obstetrics and gynecology at the Medical School of the University of Virginia.

PROMOTIONS and appointments in the faculty at Jefferson Medical College have been announced as follows: Edward J. Klopp, professor of surgery; Thomas A. Shallow, professor of surgery; George Russell Bancroft, professor of physiological chemistry and toxicology; Charles F. Nassau and Arthur E. Billings, clinical professors of surgery; George A. Ulrich, clinical professor of obstetrics; Michael A. Burns, associate professor of nervous and mental diseases; Arthur J. Davidson, associate professor of orthopedic surgery; H. Hunter Lott, assistant professor of laryngology; A. Spencer Kaufman, assistant professor of otology; Benjamin P. Weiss, assistant professor of nervous and mental diseases; James R. Martin, assistant professor of orthopedic surgery; B. B. Vincent Lyon, assistant professor of medicine; Collin Foulkrod, assistant professor of obstetrics; Lorenz

P. Hansen, assistant professor of physiological chemistry.

DR. HELENE WASTL, of the University of Vienna, has been appointed as acting professor of physiology at the Woman's Medical College of Pennsylvania; Dr. Sarah I. Morris, assistant professor of clinical medicine at the University of Wisconsin, has been made acting professor of preventive medicine and physician to the students; Dr. S. Brandt Rose has been promoted to the chair of bacteriology, and also becomes director of the clinical laboratory of the hospital; Dr. Mary J. Evans will act as assistant laboratory director. Other appointments are: Dr. Beatrice Rettinger, chief resident physician of the hospital; Dr. William John Ryan, demonstrator in surgery; Dr. Allan P. Parker and Dr. Herbert H. Fritz, instructors in surgical anatomy; Dr. William T. Lemmon, instructor in surgery; Dr. Mary Elizabeth Howe, instructor in anatomy; Dr. Miriam Butler, assistant instructor in pediatrics.

DR. FLOYD DE EDS, formerly of the National Institute of Health of the U. S. Public Health Service, has been appointed senior toxicologist for the U. S. Department of Agriculture. He will be stationed in the department of pharmacology, Stanford University School of Medicine, San Francisco, to carry on investigation of chronic intoxications for the bureau of chemistry and soils.

DAVID TWOMEY has been made assistant professor of psychology and Peter J. McKane has been made assistant professor of physics, at Boston College.

DR. WILLIAM H. GAUGER has been appointed instructor in the department of chemistry and chemical engineering at the University of Maine.

DR. CAREY CRONEIS, of the University of Chicago, has recently been promoted from assistant professor to associate professor of geology. Dr. Croneis has also been appointed research associate of the Museum of Science and Industry in charge of designing the geology exhibits in the division of geology and mineral industries. This division, when completed, will comprise 23 rooms and will occupy approximately 70,000 square feet of floor space. Mr. Louis Frederick Hampel has also joined the staff of the museum as assistant curator of social sciences.

DR. ADRIAN J. PIETERS, who has been acting in charge of the division of forage crops and diseases of the U. S. Bureau of Plant Industry, has been appointed head of the division.

PROFESSOR J. F. WILSON, wool specialist of the University of California animal husbandry division at the branch of the College of Agriculture, at Davis, California, has been chosen chairman for the 1932 conference of animal husbandmen at Miles City, Montana. The position carries with it the western vice-presidency of the American Society of Animal Production.

DR. JOHN ELTON LODEWICK, professor of wood technology at the Virginia Polytechnic Institute, has been appointed chief of the forest-products section of the Pacific Northwest Forest Experiment Station, the Forest Service has announced. He succeeds W. H. Gibbons, who was chief of forest-products work at this station for many years and who recently has been transferred to the Washington, D. C., office of the U. S. Forest Service.

DR. D. T. RIES, who until its termination on July 1 was employed by the Plant Quarantine and Control Administration on the Mediterranean fruit-fly project at Orlando, Florida, has been appointed curator of entomology at the Cranbrook Institute of Science, Bloomfield Hills, Michigan.

DR. ALBERT KENRICK FISHER, senior biologist of the bureau of biological survey, U. S. Department of Agriculture, and for many years head of its division of economic investigations, was retired on August 31. Dr. Fisher now becomes a zoological collaborator of the U. S. National Museum.

THE Charles Sumner Bacon Lectures (third series) will be given on October 8 and 9 in Lecture Hall No. 221, at the University of Illinois College of Medicine, 1853 Polk Street, Chicago, by Dr. Herbert M. Evans, professor of anatomy at the University of California. The general subject of the lectures is "The Function of the Anterior Hypophysis." These lectures will be open to the public.

DR. E. D. ADRIAN, fellow of Trinity College, Cambridge, and Foulerton research professor of the Royal Society, will deliver the Eldridge Reeves Johnson Foundation Lectures at the University of Pennsylvania from October 13 to 28 on "The Mechanism of Nervous Action—Electrical Studies of the Neurone." The series will be given in the medical clinic of the university at 4:15 on the following dates: Tuesday, October 13, "The Nerve Fiber as a Means of Communication"; Wednesday, October 14, "The Sensory Message and Its Relation to the Stimulus"; Tuesday, October 20, "The Action of Different Sense Organs; Some Outstanding Problems"; Wednesday, October 21, "Impulses in Efferent Nerves: The Grading of Muscular Contraction: Sympathetic Discharges"; Wednesday, October 28, "The Activity of the Nerve Cells."

THE spring meeting of the American Electrochemical Society is scheduled for April 21, 22 and 23, 1932, at Baltimore, the home of the largest electro-

lytic copper refinery in the world. The headquarters of the meeting will be at the Lord Baltimore Hotel. The subject for the main scientific-technical session, at which Dr. J. T. MacKenzie will preside, will be "The Electric Furnace and its Products." Manuscripts on any phase of the electric furnace art are welcome and should be mailed to the secretary before February 15, 1932. The round table discussion will be under the direction of Mr. F. A. Lidbury, of Niagara Falls. The topic of the discussion will be "Electrochemistry and the Fertilizer Industry." There have been a number of very radical changes in the fertilizer industry during recent years and an opportunity will be afforded to all members and guests to express their views and recommendations in the round table discussion. The electrothermic division is inviting one of the foremost electric furnace engineers of Europe to report upon the recent developments in the electric furnace art abroad. Dr. Duncan MacRae, of the Edgewood Arsenal, is chairman of the local committee. Trips to various industrial plants are planned, among them being the U. S. Industrial Alcohol Company, the Baltimore Copper Works, the American Refractory Company and the Bethlehem Steel Company.

THE Roumanian Medical Association held its annual congress recently in Constanza, a picturesque seaport on the shore of the Black Sea. According to the Bucharest correspondent of the *Journal* of the American Medical Association, the congress was attended by more than 700 physicians, most of them accompanied by their families. The presidential address was given by Professor Hatiegan, the minister of Transylvania. Afterward Professor Cantacuzino read a paper on Calmette's vaccination. After the paper had been read, the president of the medical association, the professorial staff of the Roumanian universities, and the different medical formations, together with the delegates of the allied professions, solemnly greeted Professor Cantacuzino on the occasion of his appointment as minister of public health. The board of the medical association established a foundation, the annual interest of which, 10,000 lei, is to be given as a prize to the writer of the best dissertation emanating from the institute for the production of serums and vaccines, carrying the name of Professor Cantacuzino. A special committee was appointed with Professor Cantacuzino as president, to award the prize.

THE permanent committee of the International Union of Forestry Research Organizations met on September 7 at the office of the Forestry Commissioners, Savile-row, England. The committee prepared for the next meeting of the international union, which is to be held in France in 1932. The union comprises over eighty forest research organizations in thirty countries. The members of the committee present were: M. P. Guinier (France), president of the international union; Herr Sven Petrini (Sweden), secretary-general to the international union; Professor H. Badoux (Switzerland), director of the Swiss Central Institute for Research; Professor L. Fabricius (Germany), director of the Institute for Research at Munich; Professor Aldo Pavari (Italy), director of the Institute for Research at Florence, and Sir Roy Robinson (Great Britain), vice-chairman of the Forestry Commission. The representatives of Hungary and Poland were unable to be present. In the afternoon the committee visited Kew Gardens, and the members were the guests of H.M. Government at a dinner at the Hotel Splendide, when Lord Londonderry presided. Later the committee visited some of the state forest areas in the west of England and in Wales.

THE Royal College of Physicians of Edinburgh will celebrate on St. Andrew's Day, November 30, the two hundred and fiftieth anniversary of its founding. The charter of the society was granted by Charles II in 1681 to a group of young physicians under the leadership of Sir Robert Sibbald.

IT has been announced recently that the Association for the Advancement of Science in Marketing has been organized. Its object will be actively to encourage a scientific approach to marketing problems. The provisional officers are as follows: *President,* Paul T. Cherrington, distribution consultant; *first vice-president,* L. D. H. Weld, research director, McCann-Suckow, Inc.; *secretary,* N. W. Barnes, Marketing Associates, Inc.; *treasurer,* A. M. Crossley.

BOWDOIN COLLEGE has received $50,000 by the will of the late Edwin Bradbury Smith.

THE late Professor W. D. Halliburton, who died on May 21, has bequeathed, on the death of his wife, £10,000 to King's College, University of London, for endowment, or towards the salary of a professor in the subject of physiology or the sciences relating thereto.

DR. HENRY G. KNIGHT, chief of the U. S. Bureau of Chemistry and Soils, has announced that a new citrus laboratory, for which funds were appropriated by the last Congress, will be established in the citrus-growing territory of the Rio Grande Valley at Weslaco, Texas, on the state-owned land of the Texas State Experiment Station. The selection of the site was made upon recommendation of Dr. F. C. Blanck, who is in charge of the food research division of the Bureau of Chemistry and Soils, and E. M. Chace, of the bureau's fruit and vegetable laboratory at Los Angeles, California, and with the approval of Di-

rector A. B. Conner, of the Texas Agricultural Experiment Station.

DR. WILLIAM FRANCIS THOMPSON, director of investigations and professor of fisheries for the International Fisheries Commission at the University of Washington, has recently completed the preliminary studies called for by a treaty in 1924 between Canada and the United States establishing a commission for investigation of the halibut fisheries. As a result of these studies, a new treaty dealing with the regulation of the fisheries and continuing the scientific work has been signed and confirmed. This is said to be the first treaty for the conservation of a species of marine fish.

DISCUSSION

THE MEGAGAMETOPHYTE OF PINUS

THE classic work of Hofmeister presents the development of the megagametophyte of several gymnosperms which he studied in the years 1848 and 1849. He introduced for the first time the general course of events in the growth of the gametophyte of gymnosperms. Subsequent corrections in this life history appeared at intervals with the progressive improvements in the methods of histological technique. Hofmeister, influenced no doubt by his study of the life history of mosses and ferns, concluded that the megagametophyte of gymnosperms grows in a manner similar to that of the Fern Allies, as he knew of it in *Selaginella*. Up to the present time this conclusion in general has been accepted by most botanists.

That the gymnosperms and Fern Allies are closely related has been seriously questioned recently by workers in paleobotany and plant anatomy. This controversy concerning the phylogeny of gymnosperms brought forth the expression that the evidence obtained from a study of plant morphology is unreliable as an indicator of relationship. Unfortunately we have only a fragmentary knowledge of a few of these life histories and none are complete in every detail.

The description of the growth of the megagametophyte of *Pinus* as presented in current botanical literature is incomplete and inaccurate. Evidence of a centripetal growth of the gametophyte has not been found in any of the gymnosperms other than *Pinus*. In *Pinus* centripetal growth has been inferred but the progress for such a development has never been presented in detail. There is too little evidence to support the general rule that centripetal growth of the megagametophyte occurs in most of the gymnosperms. In a text-book of botany of recent publication, we find the growth of the megagametophyte conveniently arranged in five stages.

> The female gametophyte, in nearly all gymnosperms, develops in a general way as in *Selaginella* and *Isoetes*. At least five stages in the development should be borne in mind; (1) Free nuclear division by which a varying number of free nuclei are distributed through the cytoplasm of the megaspore; (2) Parietal placing of these nuclei by the development of a central vacuole; (3) Continued free nuclear division; (4) Formation of a parietal tissue by the development of cell walls separating the free nuclei; (5) Centripetal growth of this tissue until it fills the cavity of the enlarging megaspore which is now known as the embryo sac.

The proper view of the development of the megagametophyte of *Pinus*, as obtained by a study of a close series of *Pinus flexilis* and *P. scopulorum* collected in the Rocky Mountain National Park, Colorado, during the past three growing seasons, differs greatly from the present accepted description. The various phases of growth will be given in the order comparable to the five stages in the previous quotation. (1) After the megaspore mother cell has divided, the first cell of the gametophyte remains in the resting stage until the zone of nutritive cells (spongy tissue) becomes active. This nutritive tissue persists for a long time in the digestion of the nucellus. (2) As a result of the activity of the digestive tissue and the enlargement of the nucellus, a large vacuole is formed. The megagametophyte develops by free nuclear division in the center of the enlarging vacuole. (3) The cytoplasm surrounding the free nuclei remains connected in strands and the young gametophyte in the center of the vacuole takes on the form of a tangled skein or network. (4) A megagametophyte consisting of a separate parietal tissue surrounding a central cavity does not appear in normal sporangia. Nutritive cells in the final stages of digestion, however, are still present in a parietal position at the time archegonia first appear. (5) The normal growth of the gametophyte is centrifugal, never centripetal. The embryo sac is completely filled by the gametophyte at the time of fertilization or soon after.

In the development of a carpellate cone of *Pinus*, two or three years, depending on the species, are required for the seeds to reach maturity. During this time interval the number of abortive ovules gradually increases as development progresses. The carpels externally appear alike at maturity but the number of seeds in a cone may vary from a few to a hundred or more. The average number of mature seeds found

is seldom as great as fifty per cent. of the total number capable of development.

At any time during the growth of the gametophyte, development may be arrested. Many megasporangia fail to renew their growth in the spring following the dormant period of winter. In *Pinus nigra* var. *austriaca* soon after the beginning of the second growing season the megagametophyte of abnormal sporangia takes on the form of a hollow sphere very much in appearance like a Volvox colony. In the process of disintegration the free cells of this abnormal gametophyte press out toward the margin of the vacuole and there assume the parietal position. These gametophytes never develop archegonia. It is possible that a person limited to material of one season may happen on abnormal ovules with the free nuclei of the gametophyte in a parietal position and later in the season he may obtain normal material with archegonia and gametophyte in a central position. From such a combination of abnormal and normal materials centripetal growth of the gametophyte might be inferred.

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PAUROPODA IN ALASKA

I HAVE been studying small and somewhat obscure arthropods of several widely separate groups, but with a number of features in common. They have no wings, they have no eyes and they live in decaying vegetable material under logs or stones or in humus. In the insect groups I have collected Campodea, Japyx and Protura. Among the centipede-like forms I have searched for Symphyla and Pauropoda.

Members of all these delicate, white, eyeless forms may all occur in one environment, but it is more common to find but one group represented in one place. I have collected from the eastern United States to the western and from Cuba and Mexico to central Alaska. The two insect genera mentioned above and Symphyla are by far the easiest to find. Pauropoda may be obtained by the funnel method or by more direct collecting in the field, but I have never found Protura except with a funnel. I did not use this apparatus in Alaska last summer, and I am not surprised that I did not find any Proturans by the methods used. They may be there; I have not really made a very serious attempt to find them. For the other groups I searched hours in a number of widely separated localities in Alaska, British Columbia and Yukon Territory and found not a single representative of any of the more easily collected animals. The only group obtained in these northern regions was Pauropoda. These were found in but four places. None were collected in southern Alaska. At Skagway several were obtained with mites, Collembola and some other insects. They were under stones in a dense wood. In comparing these with other previously collected specimens I found their nearest relationships were with some obtained the year before well up towards the timber line on Mt. Hood, Oregon. At Dawson City I was especially successful in obtaining Pauropoda. It was a slightly rainy day, moisture conditions on the ground were just right, and I was able to obtain quite a number of specimens. They were about one half way up the mountain back of Dawson City. Next at Eagle, Alaska, a few specimens were found in the woods about a mile from the Yukon.

During several days I searched in the McKinley National Park, and although mites, small centipedes and Collembola were encountered no Pauropoda were seen at any time. It may have been too damp, as heavy rains came frequently.

At Currie a few more of these minute eighteen-legged forms were found. All but one of the four lots encountered were of the genus Stylopauropus, those from Eagle alone were of the genus Pauropus. In fact more than nine tenths of all the specimens collected were of the genus Stylopauropus. In general to the southward Pauropus is more often encountered than the other.

So far as I know this record is the first for these arthropods in Alaska and so far as I have been able to learn these must be farther north than those reported from the old world. But not finding these small animals is no sure proof that they may not be present in a region. It is very easy to overlook them, as indeed all the other forms mentioned, but if one is collecting one particular kind of animal he is apt to find those which were not conspicuous. I have now collected these Pauropoda from the eastern United States, from Mexico both north and south and now from Alaska. I did not find any in Cuba, although I searched in many places.

The species found differ but little from each other, rather minor characters separate them into species. Records from others as well as those of my own suggest a world-wide distribution of two genera.

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MORE ABOUT CITATIONS

SOME comments received since the article "A uniform scheme for citations" was printed (SCIENCE, April 10, 1931, pp. 390–392) indicate the desirability of a few additional notes.

The U. S. Geological Survey scheme is applicable not only to footnote citations but to bibliographic or

other lists of publications and to synonymy. A chronologic list may be printed with the date at the beginning of each citation, as stated, or with each date centered over all the citations that belong to it. In synonymy, as the workers in any one field of biology are relatively few, an author's surname is usually adequate for identification, and for this reason it is customary to omit the author's initials unless they are needed to distinguish two authors having the same surname.

The rule in the Geological Survey citations is to change Roman numerals to Arabic figures, with the single exception of page numbers. In some publications Roman pagination is used for the preliminary matter (title page, table of contents, etc.) and the main text starts with Arabic 1, so that a publication may have, for example, both page xii and page 12. Obviously Roman page numbers can not safely be changed to Arabic in a citation. (In passing it may be said that any good reason for using the cumbersome Roman numerals in the original publications, except for the preliminary pages, would be hard to find. They are especially objectionable as used for plate numbers. "Plate CCXXXVIII," for example, is not only hard to read but occupies much space. In a publication with many plates the space saved by using Arabic numerals would be an item worth considering. It is time the Roman numerals were abandoned.)

In citing a paper contained in a serial publication the title of the paper should be included, as well as the title of the serial. A citation that gives merely the title of the serial affords no adequate clue to the subject of the paper cited and consequently does not indicate whether or not consultation of the paper itself would be desirable for a reader who wishes to pursue the subject further.

Although in citing a paper in a journal whose numbers are paged consecutively in each volume it is not necessary for certain identification to include the number (as "vol. 18, No. 3"), it is a convenience, in referring to journals that have not yet been bound, to know the particular number that contains the paper cited—that is, it may save turning over several numbers until the right one is found. This added convenience may justify the space occupied by including the number in the citation.

The page numbers given in a citation should be those containing the particular matter to which reference is made. For example, in citing an authority for a specific statement the pages on which the statement is to be found should be given—not the pages covering the whole article. Most bibliographies, however, are intended to cite complete articles or publications and should therefore give the limiting page numbers, or, for a separate publication, the total number of pages, in the form "484 pp." A bibliography recently submitted gave only the first page of the article for each citation, which, although enough information to enable any one to find the article cited, gave no clue to the length of the article—an item which might have an influence on the decision whether or not to consult it.

Where questions of priority are involved, as in descriptions of new species, the date given at the end of the citation may include the month and day of publication—if ascertainable—as well as the year. The exact date may be difficult or impossible to determine, except for a serial publication that appears at regular intervals. For other publications even a date printed on the publication itself may not be absolutely reliable, as the printer must guess it in advance, and circumstances may invalidate his guess.

Since the publication of the original article the U. S. Geological Survey scheme has been adopted by the National Bureau of Standards. The obvious advantages of uniformity would seem to recommend it to other publishing scientific organizations.

BERNARD H. LANE,
Editor

U. S. GEOLOGICAL SURVEY

VISION, AND VASCULARITY OF THE EYE

WITH the cooperation of a number of colleagues, I have made a study of the correlation of the sense of vision with the vascularity of the eye, of which this is a preliminary report. Though it is generally recognized that gross alterations in the vascularity of the retina is associated with variation of vision, it has been assumed that these variations are predicated upon damage of the retinal and choroidal tissues. It has been known, for instance, that thrombosis of the retinal artery, with resultant hemorrhages in the retina, results in loss of vision. Our study indicates, however, that there is a quantitative relation between the varying vascularity of the eye and its resultant nutritional status, and the sense of vision.

This study was suggested by parallel work on the vascularity of the ear recently published by me, and the desire to determine what effect the method utilized for altering the vascularity of the ear, galvanization, might have upon other tissues and organs of the head. In subjects with normal eyes it was not found possible to materially alter vision except by the "make" and "break" of the current, due to the rich vascularity of the eye; though it was found possible in many cases to check vision and create a sensation of "blackness" by pressure upon the carotid arteries. In cases in which the vision and the vascularity of the eye were materially reduced by disease process,

such as choroiditis and retinitis with attendant vascular thrombosis, gross changes in vision associated with parallel changes in the size of the vessels of the eye-grounds have been demonstrated. They have been induced by galvanization—negative galvanization causing dilatation of the vessels and marked improvement in vision, and positive galvanization causing constriction of the blood vessels and diminished vision. I have thus found it possible in these cases to improve sight or to reduce vision almost to the point of blindness, at will, by means of galvanic stimulation. The reversible improvement and impairment of vision as a result of dilatation and contraction of the vessels by galvanization, offers proof of the quantitative dependence of the sensation of vision upon the vascularity of the eye. In a number of cases with rapidly failing vision, it has been found possible, by means of galvanic therapy, to improve the sight of the subject to a useful level and to maintain at that level for long periods of time.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

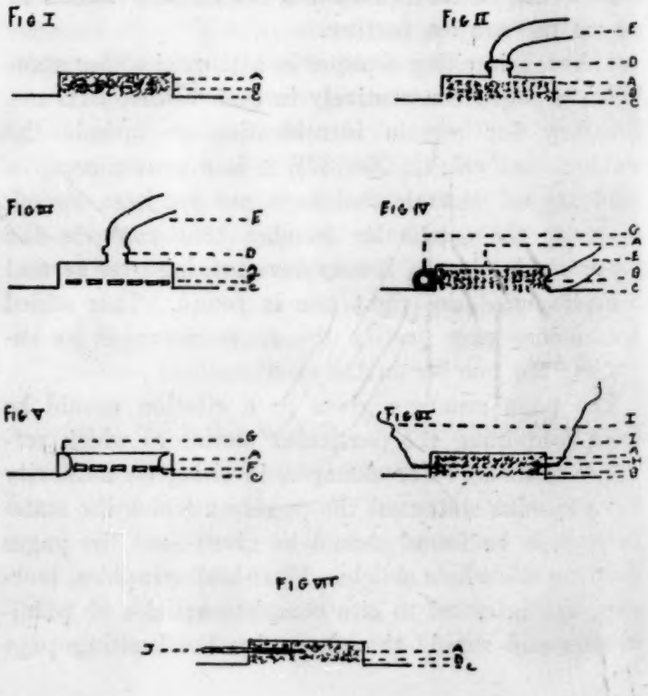
ABSORPTION DEVICES AND METHODS

THE devices and methods for the collection of sweat thus far improvised are somewhat complex. In addition there are many extraneous forces which might influence the collection. For example, sweat collected from an individual placed over a rubber sheet is subject to contamination by secretions other than those from the skin. An arm surrounded with a jacket subjects the part to abnormal production. Sucking up sweat by a syringe is cumbersome and although it is of little value for quantitative estimation, good qualitative results are obtained.

The author proposes other means and methods for the collection of sweat for qualitative and quantitative estimation. It is our opinion that the perspiration of an individual is a very important factor in his well-being and that any practical method for the collection and estimation of the amount secreted in the various parts of the body should have great prognostic and diagnostic value. First, however, it is necessary that the method be simple and accurate and furthermore, that the apparatus be so constructed that it may be applied to any part of the body over a measured area of skin or mucous membrane. The logical method of accomplishing such results presents itself in the form of a chemically inactive but efficient absorbent which can be placed in a cup (made of chemically inert material), the opening of which has a definite known area and which opening can be apposed to a given skin surface. This cup can be constructed of varying shape and size so as to fit the site to which it is to be applied. Likewise the absorbent is cut so that it fits snugly over the area. In order that the quantitative results may be estimated, the absorbent is weighed before and after applying to the skin surface and the time of application noted. For qualitative estimation it is necessary to know the chemical composition of the absorbent, to extract the absorbent, test the extract qualitatively and therefrom compute the results.

It must be realized that normally the amount of sweat secreted varies with the metabolism of the individual, the construction of the skin, the part of the body, the temperature and humidity of the environs, the circulation of air, the cleanliness of the parts, the type and amount of clothing, the diet, etc. We must also note that sweat will vary qualitatively and quantitatively in certain pathological conditions. In addition, sebaceous glands, epithelium and the predominant type of sweat gland will influence the composition of sweat in the different parts and under different conditions. In order that all factors be taken into consideration it is necessary that the cup containing the absorbent be varied in construction and that the methods be altered so as to fit the need.

For the above reasons the author has illustrated the simple and altered types of cup with absorbent. The cup in each case can be fastened to the skin surface by adhesive, belt, elastic or whatever means may best suit the part to which it is to be applied. We first used vaccination shields, the holes of which had



been closed and the shields varied to suit the occasion. Specially prepared and analysed J. & J. cotton was the absorbent used. The absorbent was cut to the circumference of the cup and was weighed before and after application and the difference and time noted.

DESCRIPTION OF DEVICES:

Fig. I—Cross-section: A is the cup, B the absorbent and C the flange which fits to the surface.

Fig. II—Cross-section: A is the cup, B the absorbent, C the flange, D the neck of the cup and E a tube leading from the neck which can be secured to the same either by threads or other suitable means or can be made continuous with the cup. The purpose of the tube E is to produce pressure or vacuum in the chamber by its being connected to a pump or other device for that purpose.

Fig. III—Side view: A is the chamber, C the flange, D the neck of the cup, E the tube leading off from this neck and F are apertures in the side of the cup. In this cup is contained the absorbent. E is connected with a suction or pressure device. This method produces a circulation of air in the cup because of the apertures F. The cup may be constructed with an additional part so that the apertures can be closed and in that way its purpose will be identical with that of Figure II.

Fig. IV—Cross-section: A is the cup, B the absorbent, C the flange, E is a tube connected to a channelway G running around the cup and opening into the cup by means of slits. The tube E can be connected with a pressure or a vacuum device so as to produce negative or positive pressure in the cup or there may be holes in the top of the cup so that a circulation of air is produced. The top may be so constructed that holes in it can be opened or closed.

Fig. V—Side view: This is a side view of Fig. IV in which A is the cup, C the flange, G the channelway around the cup and F openings from it into the cup.

Fig. VI—Cross-section: A is the cup, B the absorbent, H an electrode imbedded in the absorbent and I the wires leading from the electrodes. The principle of this device is to measure the conductivity through the absorbent as the perspiration is being absorbed.

Fig. VII—Cross-section: A is the cup, B the absorbent, C the flange and J is a thermometer. The principle of the thermometer is to measure the temperature change in the absorbent. In this case the cup can be made of non-heat conducting material as desired.

The measurement of the amount of sweat in a given length of time and from a given area under similar and varying conditions is the aim of the above devices and procedures. The additional factor that the devices described are simple, easily applicable over a given area from which sweat is desired, and the estimations are not complicated should add to their practicability and assure their early usage. Certainly this procedure is less complex than many which are daily routine in the well equipped hospitals of to-day. In a later paper the author will discuss variation in the secretion of sweat under diverse conditions.

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DOUBLE PLATE METHOD USED FOR CULTURING TILLETIA LEVIS

A NEW procedure has been followed whereby pure cultures of *Tilletia levis* may more easily be made. The bottom of a petri dish is covered with a two per cent. potato dextrose agar and allowed to cool until all the moisture is gone from the top of the plate. Then the top of the dish is poured with a three per cent. non-nutrient agar somewhat cool. The agar is poured in the center of the lid until an area about one and one half inches in diameter is covered.

Streaks of sterilized smut spores are made across the non-nutrient agar with a loop needle. These are then incubated for ten days at 12° to 14° C.

As is well known, the sporidia of *Tilletia levis* are ejected from the sterigmata and in the double plate they fall to the nutrient agar below where they can be picked off singly or grown into multisporidial cultures free of contamination.

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SPECIAL ARTICLES

INBREEDING IN ALFALFA ESTABLISHES A HIGH DEGREE OF HOMOZYGOSITY[1]

A PREVIOUS report[2] of alfalfa-seed investigations at the Utah Station indicated that about 2 to 2.5 times as many pods were set when artificial tripping was practiced. A considerable number of pods developed from flowers which showed no evidence of having been tripped.

An inbreeding experiment of considerable proportions, the data from which are just now available[3] make clear that alfalfa in one of the famous seed-growing areas in the Uintah Basin, Utah, is much less heterozygous than has been thought. As conducted, the experiment did not establish what proportion of the seed pods developed under conditions of natural self-fertilization. Although this would be difficult to

[1] Contribution from Department of Agronomy, Utah Agricultural Experiment Station. Publication authorized by director, June 15, 1931.

[2] Carlson, J. W., "Artificial tripping of flowers in alfalfa in relation to seed production," *Jour. Amer. Soc. Agron.*, 22: 780–786 (1930).

[3] Carlson, J. W., and Stewart, G., "Alfalfa-seed production," Utah Agr. Exp. Sta. *Bul.* 226 (1931).

do on purely positive evidence, a good beginning has been made. After generations of inbreeding, however, a study of eight different plant characters in each of 154 inbred strains, fully 50 per cent. of progenies were practically homozygous for one or more of the characters. Such a degree of homozygosity makes evident a considerable amount of self-fertilization in the generations immediately preceding the self-fertilization.

The inbreeding was brought about by putting paper bags over flowering branches of the alfalfa plant before the blossoms had opened. Branches were selected on which the tips of the blooms were well out of the bud; any flowers that were mature enough to have begun to open were clipped off, thereby enclosing in the bag only those flowers which had had no opportunity for cross-pollination. Parent plants of the following varieties were grown in rows three feet apart and with plants 27 to 40 inches apart in the row: Utah Common, Dakota Common, Grimm, Grimm Saskatchewan 666, Hardigan, and Ontario Variegated. These varieties represent a wide range in size, coarseness, leafiness, and erectness.

Seed production under bags, as a rule, is relatively poor, but in seasons moderately favorable for seed-setting, some seeds are obtained from most plants on which five to ten bags have been placed. In 1927, when the bagging was done, a few plants failed to produce any seeds under bags even when seeding well in the open air. Of approximately 180 plants so bagged, seeds were obtained from 154, of which 88 produced 50 to 100 seeds under bags. In 1928, the selfed seed from each parent plant was seeded in a single row of 50 plants when there were enough seeds. When the number of seeds obtained was fewer than 50 all of them were sown, one in a place. There were a few rows with only one to five or six plants, though in most cases 10 to 40 plants were obtained.

When these first-generation plants from self-fertilized seeds bloomed for the first time, some of them were bagged in order to produce second-generation selfed seed, from which progeny rows were seeded in 1929.

In 1929 it was observed that of the progeny grown from selfed seed, plants in some rows were variable, fully as much so as were the commercial varieties, whereas the progeny in other rows seemed to be much more uniform in erectness, in height, in diameter of stem, in size and shape of leaves and in color of blossoms and foliage. Measurements were taken of 40 plants in each of the parent rows and of all the plants in the progeny rows. Five rows of the Utah Common variety were measured—two near the breeding plats and one each from three different parts of the field but some rods away. Data were taken from each plant as to height, width, angle of erectness, diameter of a main stem three or four inches above the ground, leaflet length, leaflet width, color of the blossoms and color of the foliage. The colors were read from a standard color chart and assigned numerical values with the help of an artist. The variability of each row was computed as the standard deviation and as the coefficient of variability.

The variability of the varieties is reported in Table 1 with the variability expressed in percentage of the mean values of each character studied. Though the mean values differed widely, only the variability is reported in order to show uniformity or lack of it.

TABLE 1

COEFFICIENTS OF VARIABILITY OF PLANT, STEM, LEAF AND BLOOM CHARACTERS OF ALFALFA VARIETIES WITH 40 PLANTS IN EACH ROW MEASURED

	Percentage						
	Plant height	Plant width	Angle of erectness	Diameter of stem	Length of stem	Width of leaflet	Color of bloom Standard deviation
Utah Common	19.7	18.5	22.4	11.2	12.2	18.0	2.93
"	22.2	18.8	18.0	18.4	15.1	25.7	3.03
"	19.9	26.0	21.7	17.1	13.4	26.8	3.35
"	16.6	24.4	12.0	15.3	17.6	23.7	3.59
"	21.8	26.1	17.0	18.0	13.2	21.8	2.65
Grimm	22.9	26.9	15.0	18.8	17.2	23.6	10.80
Grimm Sask. No. 666	26.9	31.4	25.3	19.2	17.6	24.8	6.66
Hardigan	22.0	24.2	14.2	19.3	14.9	25.7	5.87
Dak. Common	21.9	25.8	7.6	16.2	12.1	21.4	2.37
Ont. Variegated	25.0	25.3	20.0	20.8	17.8	21.3	6.66

The result of one generation of inbreeding is summarized in Table 2 where the variability is reported for progenies. Comparing plant height and width in the two tables, it is clear that some of the progenies are similar in variability to the parent varieties while others are distinctly more variable and others distinctly less. This is true of each character studied, even for blossom color. There is every evidence of segregation of distinct strains of alfalfa at the end of the first inbred generation. This indication is so definite that high hopes are held for producing improved sorts after several generations of inbreeding. The second inbred generation shows rather marked tendencies to the further purification of some strains, but since these are not yet available they can be only noted here.

TABLE 2

VARIABILITY OF PROGENY ROWS OF ALFALFA, EACH GROWN FROM SELF-FERTILIZED SEED OF A SINGLE PLANT. THREE PLANTS EACH OF THE HIGHEST, OF INTERMEDIATE, AND OF THE LOWEST VARIABILITY OF EACH CHARACTER

Variability group	Plant height	Plant width	Angle of erectness	Diameter of stem	Length of leaflet	Width of leaflet	Color of bloom
Highest	38.2	45.6	50.7	25.7	27.5	23.7	12.19
"	36.7	43.8	46.2	22.0	26.8	29.6	10.64
"	30.8	39.4	44.6	21.1	18.9	28.8	10.15
Intermediate	20.8	22.9	21.1	14.2	12.6	16.7	4.35
"	19.9	20.8	23.1	13.8	11.9	16.7	3.83
"	18.4	21.2	19.5	13.3	11.2	15.5	3.33
Lowest	9.3	11.0	8.6	8.5	7.1	11.2	1.22
"	9.6	11.2	7.8	6.1	6.6	10.3	1.10
"	7.9	7.5	7.0	4.5	4.8	9.0	0.0

Inbreeding which tends to purify the various subvarieties, or strains which make up a variety, allows for the appearance of any abnormalities which in open pollination (such as occurs in the field) are obscured by being in a crossed condition with normal types. In the first inbred generation, three rather distinct sorts of abnormal plants have appeared.

Each of two progenies, both from the same parent strain, showed several plants on which the leaflets had tiny brown markings not characteristic of any recognized disease when examined by a plant pathologist. The leaves, partly folded and partly crinkled, suggested that small sections of the leaf structure had been lost or had died after development had started. Sufficient study has not yet been made to enable more to be said at the present time.

In three other progenies there occurred some distinctly shorter plants extraordinarily leafy but which would produce only about half as much hay as the parent variety. One strain of nearly normal size showed in a large degree this same condition of extreme leafiness.

In a single progeny almost half the plants had the blossom replaced by a freak vegetative development that resembles somewhat the appearance of the flower buds on a plant of seed onion. This condition occurs naturally in the field at rare intervals. Here a progeny was found in the first inbred generation in which the character was thousands of times more frequent than is found in the commercial varieties or strains.

Some strains are becoming pure for erectness, while others are pure for a nearly flat position; others are showing a strong tendency to coarseness and others to a suggestion of "vininess" in the upper branches. This last character suggests a faint resemblance to twining branches such as occur on vetches and some beans.

There is also considerable evidence that seeding ability in certain strains is governed in part by the genetic constitution of the plants.

While an immense amount of careful scientific work would be required to develop and maintain economic strains, the promise is such as to warrant its being given a thorough trial.

GEORGE STEWART[4]

NON-ACID-FAST TUBERCLE BACILLI

NON-ACID-FAST organisms long have been known to exist as a phase in the life cycle of the acid-fast group. Until recently no pure cultures of the non-acid-fast varieties have been obtained. It has been thought that the occasional non-acid-fast rod and the forms described as Much's granules[1] were involution forms which had lost their acid-fast property. From Kahn's recent work,[2] it would appear that these granules were the precursors of numerous young organisms. Recently Dreyer and Vollum[3] reported the cultivation of a non-acid-fast strain of human tubercle bacilli which showed optimum growth at the bottom of veal peptone bouillon medium. These organisms were fully virulent.

In this communication we describe a non-acid-fast, almost a virulent type of organism which has much in common with the acid-fast strain from which it was isolated.

A two-months-old culture of H-37 strain of human tubercle bacilli developed a group of yellow-orange, chromogenic colonies in the midst of other normal-appearing colonies. These chromogenic colonies appeared to have the same morphological characteristics as the known acid-fast ones surrounding them. They were made up of numerous non-acid-fast rods and granules and were Gram-positive. There were also present a few acid-fast rods and granules, and some of the non-acid-fast rods contained from one to three acid-fast granules.

Three subcultures were made at different times from the original colonies. The cultures grew rap-

[4] Formerly Agronomist; now Senior Ecologist, Intermountain Forest and Range Experiment Station, U. S. Forest Service.

[1] H. Much, *Beitr. z. Klin. d. Tuberc.*, 8, 85, 1907.

[2] M. Kahn, *Amer. Rev. Tuberc.*, 20, 150, 1929.

[3] G. Dreyer and R. L. Vollum, *Lancet*, 220, 1015, 1931.

idly, attaining a maximum growth in ten days. During the first five days they were first yellow-white, then yellow, and by the tenth day they were a deep orange color. Each of these subcultures had the general morphological characteristics of the acid-fast group. They were composed of numerous rounded colonies, and occasionally one or more of these was piled on one another. The edges of the growth were usually smooth and at times became indented as the growth progressed. The staining characteristics were the same as the original colonies. Dilution cultures were made to obtain single colonies. After dilution growth appeared in two days. This was in the form of white, rounded colonies which did not start to assume the yellow color before the fourth or fifth day. By the tenth day they had attained a maximum growth and a deep orange color. The rounded colonies, by the third or fourth day, showed from two to five lobulations which gave the appearance of dividing starfish eggs. None of these showed the crusting projections found in many of the colonies of the acid-fast group. All appeared on the surface of the medium and did not cause lysis of it. By the end of the sixth week each colony had developed a fine, veil-like growth, orange in color about its base. These were very similar to those seen about the bases of many single colonies of acid-fast organisms. At the tenth day, sixth week and third month the organisms stained the same as those of the original colonies, except that there were fewer acid-fast rods to be found.

The organism grew easily and rapidly on blood agar; it made almost a complete growth in five days, and showed no further growth after ten days. On this medium it had lost its chromogenic power and appeared as dirty white, slightly heaped-up colonies. Often these had a moth-eaten appearance and irregular borders. They had about the same appearance on plain agar, although some piled up in clean white, rounded groups. On these media they were entirely non-acid-fast and were of a coccoid, granular type, slightly larger than ordinary cocci, although a few rods the size of acid-fast organisms still were present.

The organism gave a luxuriant growth on Long's medium. It formed a pellicle on which rounded, granular, light-orange colonies developed. Many of these granular colonies sank to the bottom of the flask, but others developed in their place on the pellicle. These again were almost wholly non-acid-fast rods, although a few acid-fast granules were present. The growth was less luxuriant on plain and dextrose broth, and in these two types of medium it was found at the bottom of the tube as a dirty white precipitate. Growths of this sort were made up of the non-acid-fast, coccoid granular organism.

Five guinea-pigs were inoculated with suspensions of the second generation of the chromogenic organism. Each pig was given 1/50 of 1 mgm subcutaneously in the right groin. Four weeks after this inoculation, all were in excellent condition and were reinoculated with 1 mg of the same culture. This was again given subcutaneously in the right groin.

Of these five animals, two at autopsy had no demonstrable tuberculosis. The other three had caseous nodes at the sites of inoculation and varying numbers of tuberculous lesions in spleens, livers and lungs. Acid-fast rods were demonstrated in smears from the caseous material, as well as in smears of the affected organs. The amount of tuberculosis each animal had was much less than would be expected following a much smaller dose of our parent strain of H-37 human tubercle bacilli.

We believe that this organism is a non-acid-fast mutant of our strain of H-37 human tubercle bacilli. Although chromogenic, it maintains cultural characteristics similar to the acid-fast group when grown on special media. Its growth on simple media is composed almost entirely of non-acid-fast granules. Granular forms may be the primary type of organisms of the acid-fast group, with the chromogenic organism as an intermediate phase, and the acid-fast bacillary forms the typical, well-known varieties.

We also have evidence that sterile Berkefeld filtrates of cultures of the chromogenic organism will cause normal cultures of human and bovine tubercle bacilli and timothy grass bacilli to lose their acid-fastness and grow as forms similar to the coccoid granular type of the chromogenic mutant.

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BOOKS RECEIVED

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